Spawning and Early Life History of Herring and Capelin in St. Georges Bay, Nova Scotia

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SPAWNING AND EARLY LIFE HISTORY OF HERRING AND CAPELIN IN ST. GEORGES BAY, NOVA SCOTIA

by

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ABSTRACT

Herring enter St. Georges Bay in spawning waves roughly 21 days apart. Consecutive cohorts of larvae result; in 1973, eight of these could be detected in the plankton between May and December. During spring and autumn, larvae are hatched in St. Georges Bay, whereas summer contingents are immigrant and originate in the Pictou region.

There was an unusual occurrence of capelin in St. Georges Bay from 1975-1978. Spawning was similar to herring in that several cohorts were released at regular intervals. Capelin cohorts were more closely spaced (about 10 days) than herring cohorts; spacing appeared to be a function of both larval mouth size and growth rate.

Herring larval abundance and size was well correlated with zooplankton abundance and size. Reduction of interspecific competition between the larvae of herring and capelin appears to be achieved by limiting the occurrence of larvae of the same size at the same depth.

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Le hareng pénètre par vagues, à intervalles d'environ 21 jours, dans la baie St-Georges pour y frayer. Il en résulte des cohortes successives de larves; entre mai et décembre 1973, on a détecté huit de ces cohortes dans le plancton. Au printemps et en automne, les larves éclosent dans la baie, tandis que les contingents estivaux sont des immigrants provenant de la région de Pictou.

De 1975 à 1978, il y eut présence inhabituelle de capelan dans la baie St-Georges. La ponte de cette espèce a ressemblé à celle du hareng, en ceci que plusieurs cohortes ont été libérées à intervalles réguliers. Les cohortes de capelans étaient plus rapprochées (environ 10 jours) que celles du hareng; l'espacement semble être fonction à la fois de l'ouverture de la bouche des larves et du taux de croissance.

L'abondance et la taille des larves de hareng sont étroitement liées à celles du zooplancton. La compétition interspécifique entre hareng et capelan semble réduite par limitation des larves des deux espèces de même taille à la même profondeur.

INTRODUCTION

A comprehensive investigation of fish eggs and larvae in St. Georges Bay, Nova Scotia was initiated in 1973. Preliminary sampling revealed the presence of more than 20 species exhibiting a seasonal succession of spawning. Four commercially important species were selected for detailed study: Atlantic mackerel, Scomber scombrus; Atlantic herring, Clupea harengus; capelin, Mallotus villosus, and white hake, Urophycis tenuis. Annual variation in abundance, growth and mortality were determined for four years, with a hope of relating these to environmental factors and subsequently recruitment.

Data collected on herring and capelin proved to be of particular interest. In addition to previously recognized spring and autumn spawning herring stocks, a third group was detected spawning in late summer. Also, for the first time on record, capelin entered St. Georges Bay and spawned in 1975 and thereafter for two subsequent years.

St. Georges Bay, approximately 30 km square, lies to the west of the Straits of Canso at the eastern end of Northumberland Strait (Fig. 1). The bay is generally ice-covered for about two months but rapidly warms in late spring and attains surface temperatures in excess of 20° by mid-August.

Running NW-SE through the bay is a 30-40 m deep trough with sediment ranging from silty to sandy mud; the greater part of the bay (mean depth 20 m) has a bottom ranging from rocky outcroppings through gravel to sand (Kranck, 1971).

St. Georges Bay supports several fisheries, the two main ones being for lobster and hake. Scallops are dragged along the western shore and mackerel and herring are taken seasonally.

There is little fresh water runoff into the bay so salinity is a relatively constant 30°/oo, being representative of the southern Gulf of St. Lawrence. A strong west to east flow across the north causes a clockwise circulation within the

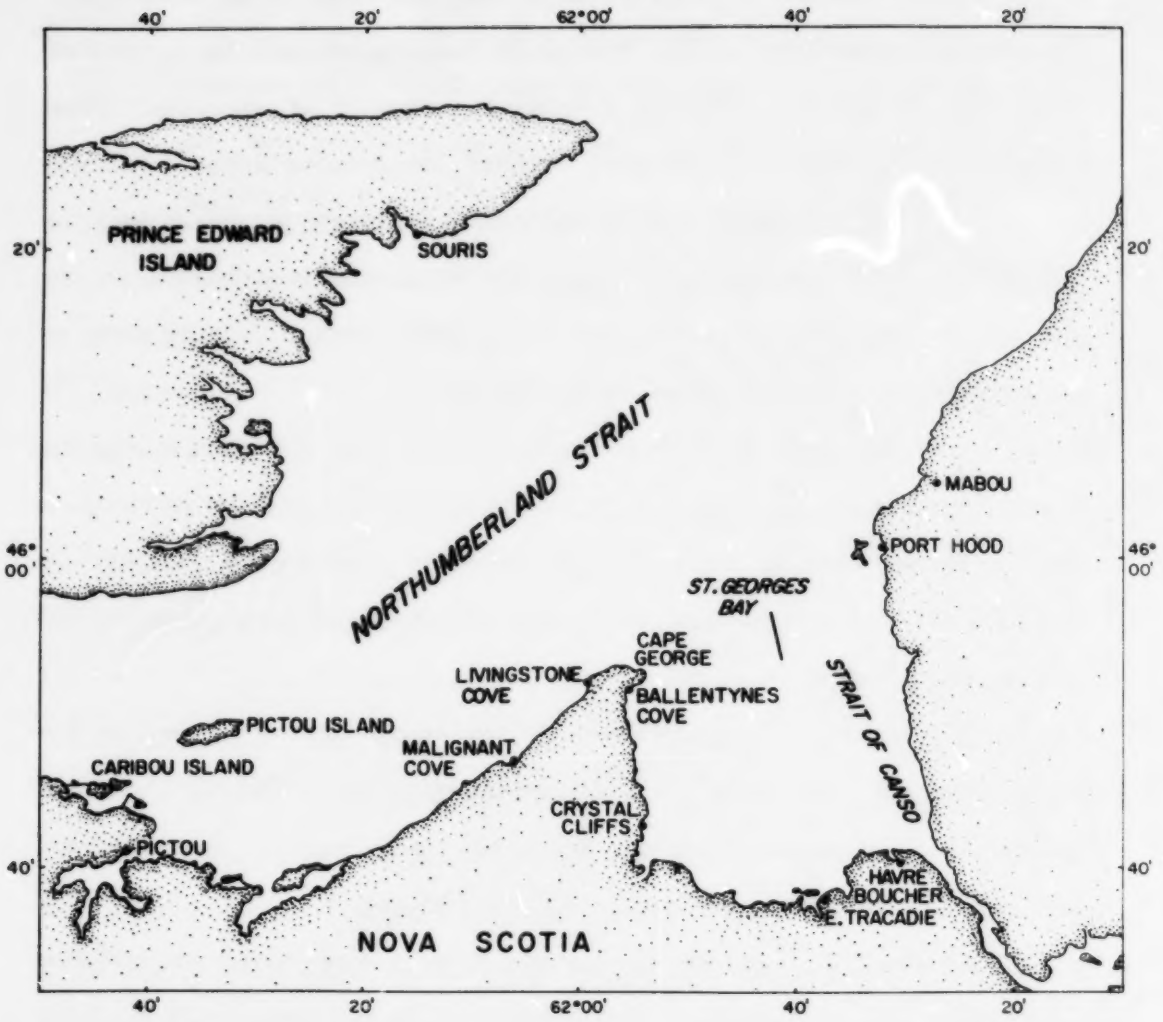


Fig. 1. Location of St. Georges Bay in northwest Nova Scotia

bay (Petrie and Drinkwater 1978) which tends to retain planktonic organisms and reduce exchange with Northumberland Strait. Thus, being able to sample the same population over a period of time, we were confident that our estimates of growth and mortality would be reliable.

MATERIALS AND METHODS

A variety of sampling gear was used varying slightly from year to year. The mesh size of all nets was 405 µm, except for vertical samples which were 80 µm. All horizontal tows were one nautical mile in length (4 knots for 15 minutes). At the end of each station the boat was stopped, a vertical tow made with a ½ metre diameter ring net and a bathythermograph lowered.

In 1973, a neuston net (Sameoto and Jarosynski, 1969) and 6 foot Isaacs-Kidd mid-water trawl (IKMT) were used to sample the surface and 10 m layers respectively. In 1974, the neuston net (surface), ½ metre diameter ring nets (5 and 10 m) and the IKMT (oblique) were towed; this arrangment was used again in 1975 but without the 5 metre sample. In 1976 three horizontal tows were taken at 0, 5 and 10 m but the IKMT was omitted. Also this year all sampling was done at night, whereas in other years sampling was completed during daylight. The IKMT was towed from approximately 2 m off the bottom to the surface during an oblique haul. The average bottom depth was 20 m. Concentrations of organisms below 10 m were derived by subtracting upper layer concentrations from IKMT values (see Appendix I). This derived value was considered the concentration at 15 m.

The system of sampling was based on random selection from a grid. For a more detailed account of station positioning and in-laboratory sample processing see Lambert et al. (1982).

Data on adult fish were for the most part collected at Ballantynes Cove, Havre Boucher and Port Hood. Commercial fishermen recorded catch data and provided samples for length/frequency and sexual maturity determinations. The maturity stage scale of the ICES Herring Committee (Anon. 1962) was adopted. (See Appendix II).

HERRING ADULTS

Abundance and spawning

Although herring can be caught during most of the year in St. Georges Bay, they are most abundant during May and September, the spring contingent historically being the larger (Fig. 2; also Tibbo et al. 1969). Twenty years ago

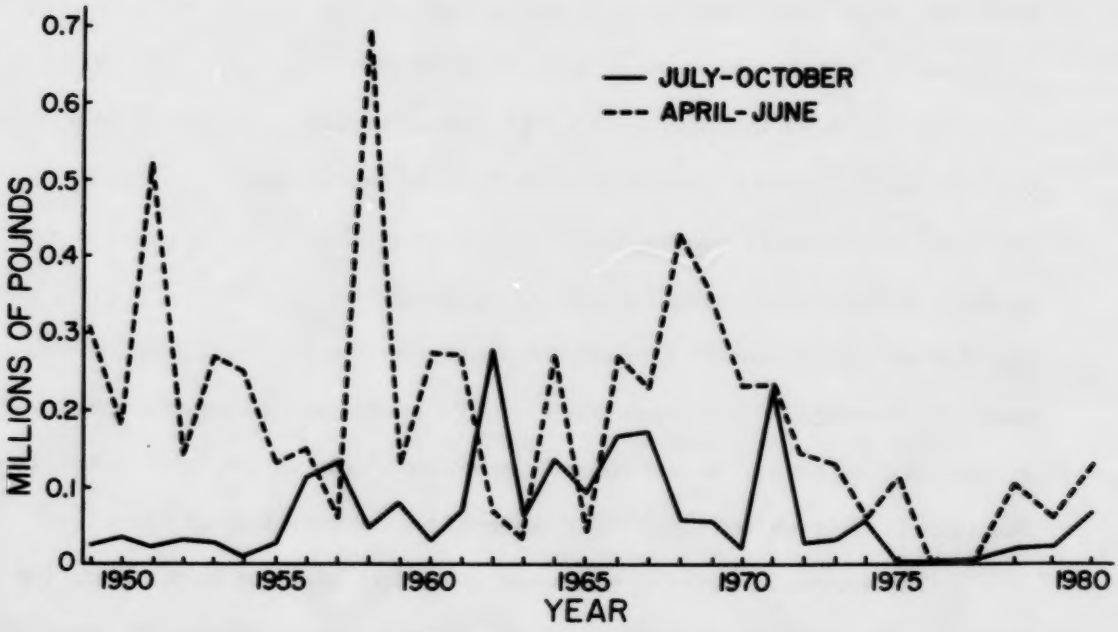


Fig. 2. Spring and autumn herring landings, Antigonish County

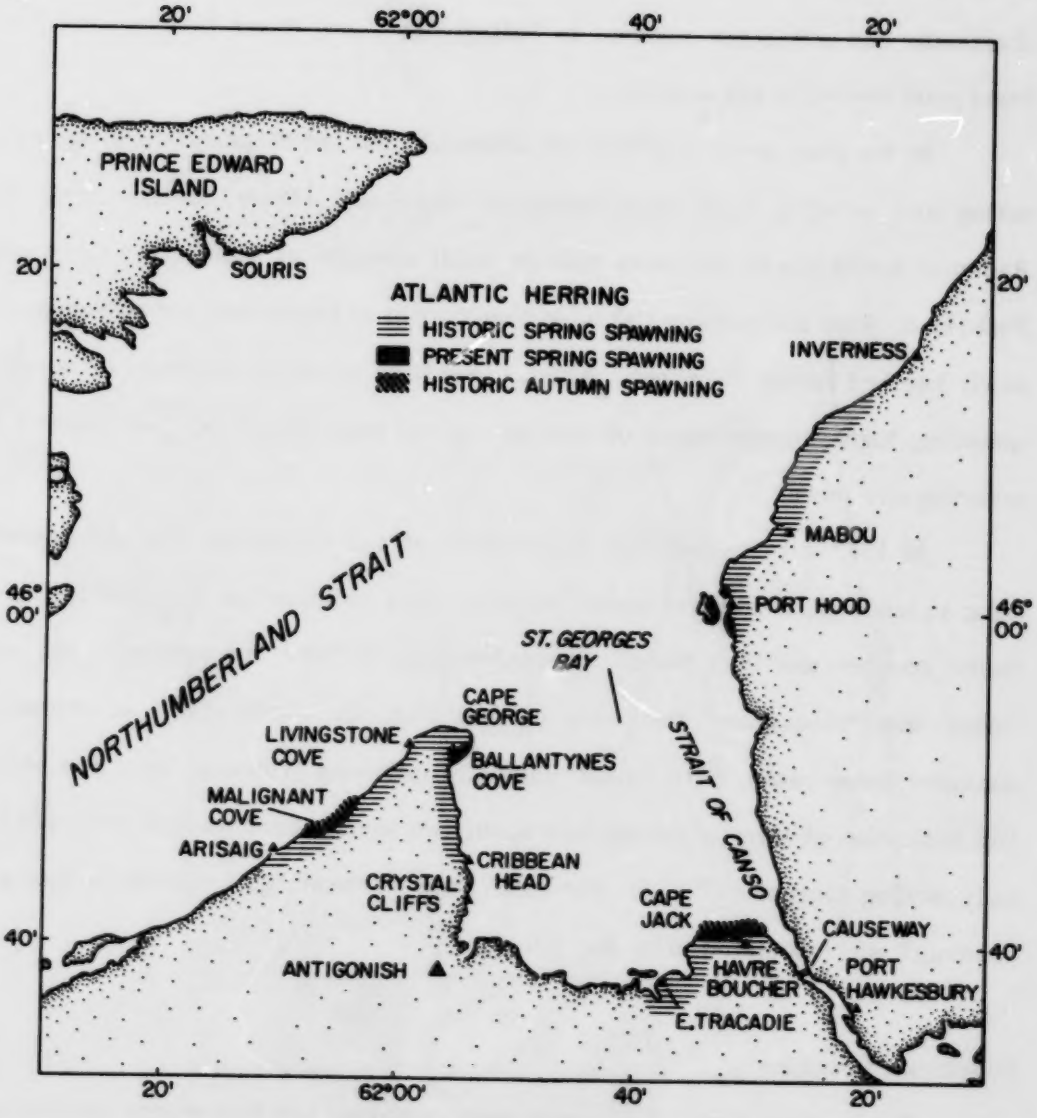


Fig. 3. Spring and autumn herring spawning grounds; past and present.

herring were caught in great number from Arisaig around Cape George to Cribbean Head; from Tracadie around Cape Jack to the Strait of Canso, and from Port Hood northeast along the Cape Breton shore. Today both stocks have declined drastically and only areas adjacent to Ballantynes Cove, Havre Boucher and Port Hood yield herring in any quantity.

In the past, according to local fishermen, the largest spawning sites, both spring and autumn, were near Malignant Cove and Havre Boucher (Fig. 3). Recently spring spawn has been seen in small amounts at Ballantynes Cove and Port Hood. Ripe and running fish have been caught in September and subsequently newly hatched larvae collected. Although we have no direct evidence of autumn spawning, high concentrations of yolk-sac larvae near Havre Boucher suggest a spawning site there.

In 1977 a more detailed examination of the spring run was undertaken. Data on landings, length and sexual maturity were collected at Ballantynes Cove, Havre Boucher and Port Hood. The percentage of "ripe and running" fish, and "spent" and "recovering" fish were plotted (Fig. 4). Both stages of maturity displayed three peaks, with "spent" logically following "running" by a few days. This indication of three spawning runs about two weeks apart was corroborated by daily landing statistics (Fig. 5) The mean date of spawning, weighted by biomass (landings), was calculated to be May 24.

Population Structure

The landings from all gill nets were combined and histograms constructed for the time periods encompassing the three spawning runs. Each polymodal population was resolved into components according to Harding's method (1949), modified by Cassie (1954). In each period six year classes could be separated

(Table 1). These compare favourably with the mean length at age values for southern Gulf of St. Lawrence herring from 1966-1968 inclusive (Tibbo et al., 1969).

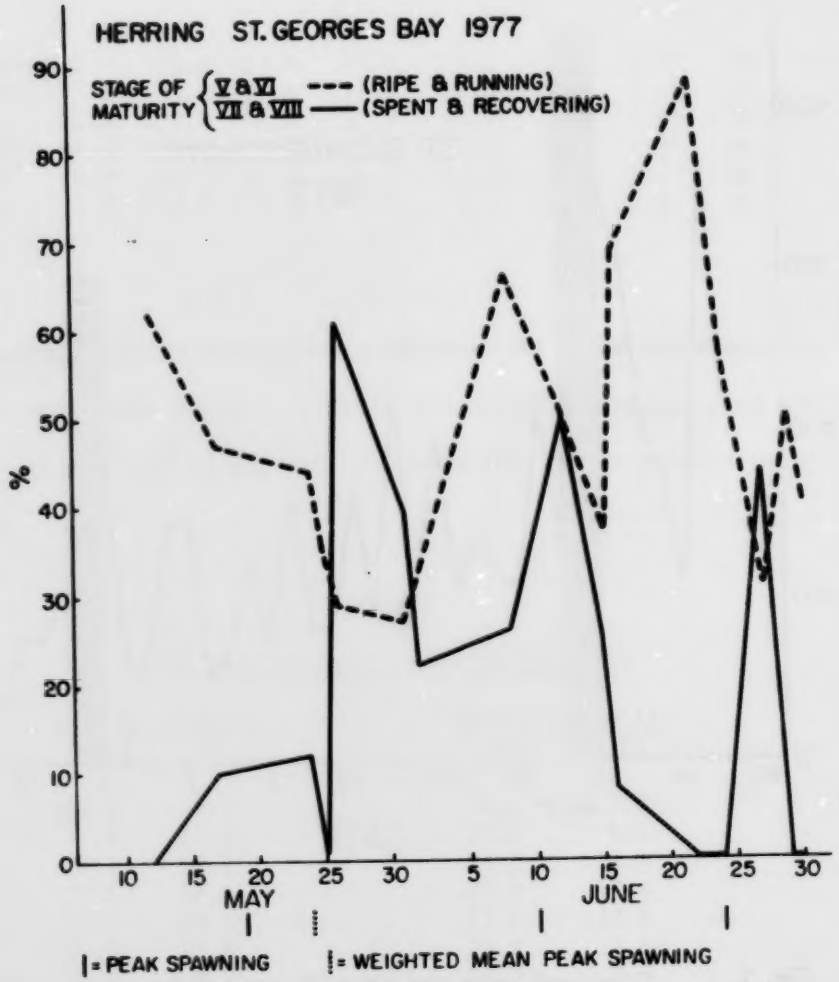


Fig. 4. Relative proportion of pre and post spawning condition herring during the spring run in St. Georges Bay, 1977.

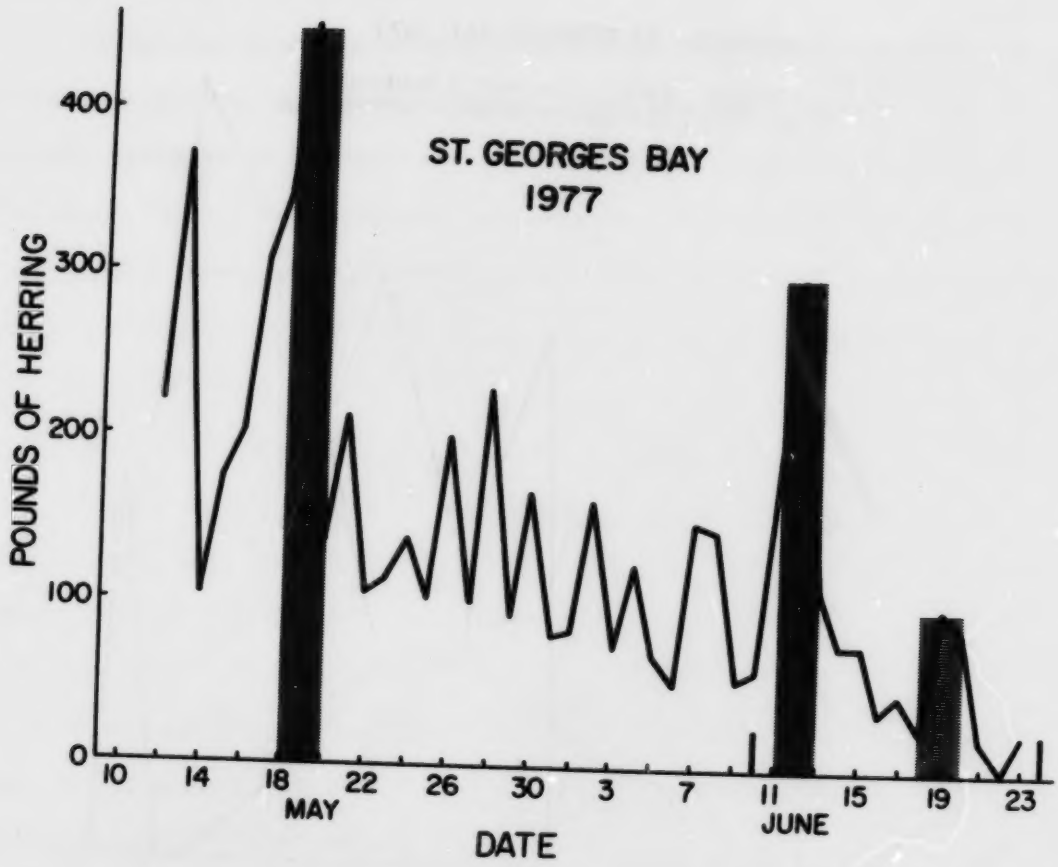


Fig. 5. Combined (trap and gill net) mean daily landings of herring St. Georges Bay, 1977.

Hatched bars are peak landings which correspond to times of peak spawning (heavy vertical lines on abscissa).

TABLE 1

Gill Net Catches St. Georges Bay 1977

Age	May 11-June 2		Jun 3-Jun 17		Jun 18-Jun 30		Mean (SD)		S. Gulf St. Lawrence 1966 - 1968	
	cm	%	cm	%	cm	%			Mean	(SD)
8	33.5	2.5	32.4	13.8	33.6	4.8	33.2	(.7)	32.1	(1.3)
7	32.0	15.3	31.2	21.8	31.8	17.5	31.7	(.4)	31.5	(1.4)
6	30.1	28.8	29.8	26.4	29.8	34.9	29.9	(.2)	30.5	(.2)
5	27.9	35.0	28.0	23.0	27.7	27.0	27.9	(.2)	29.1	(.5)
4	26.5	14.7	26.3	12.6	26.3	11.1	26.4	(.1)	26.7	(.4)
3	25.0	3.7	25.1	2.3	23.6	4.8	24.6	(.8)	24.4	(.3)

Trap net landings at Ballantynes Cove were subjected to the same analysis. The results were essentially the same with the addition of a two-year class which was retained by the fine mesh of the trap but not by the coarser mesh of the gill nets (Table 2).

TABLE 2

Trap Net Catches St. Georges Bay 1977

Age	May 11 - June 2		June 3 - June 17		Mean
	cm	%	cm	%	
8	34.6	4.2	32.6	5.9	33.6
7	31.8	11.1	30.7	8.2	31.2
6	29.2	16.7	29.2	5.9	29.9
5	27.6	21.5	27.7	17.6	27.7
4	26.1	23.6	25.4	37.6	25.7
3	24.7	18.8	24.0	17.6	24.3
2	21.4	4.2	22.8	7.1	22.1

The preponderant group in the gill net catches consisted of 5 and 6 year old fish whereas 4 and 5 year old fish made up the bulk of the finer mesh trap net catch.

There was no significant difference between the von Bertalanffy parameters (L ∞and K) of the three spawning runs hence the conclusion drawn from the length frequenty data is that the "spring" herring are a discrete group arriving and spawning in St. Georges Bay in at least three runs.

HERRING LARVAE

Abundance and Population Structure

The majority of larvae were collected between September and December (Fig. 6). Sampling was terminated early in 1975 and bad weather caused undersampling in the fall of 1976 so estimates of larval abundance during the latter part of either year are not reliable.

Frequency histograms revealed polymodality in the larval populations. Component or sub-populations were separated and the mean length for each plotted according to the technique of Harding (1949) and Cassie (1954). Best linear fits to these mean lengths over time revealed a number of larval contingents hatched at 2-3 week intervals (Fig. 7). The slopes of these lines indicate the growth rates of the respective larval groups. As expected, the growth of larvae during the summer was higher than during colder months. The mean growth rate of all components during 1973 and 1974 was 0.20 mm/day (S.D. 0.02).

Since spring spawning occurs at present in St. Georges Bay during May, the earliest larval contingents were assigned to this group using mean time of arrival of spawning adults, and hatching time (Das 1968) at the mean water temperature then prevailing at 10 m depth. The presence of yolk-sac larvae, particularly in areas where spawning has been recorded in the past, indicate present day spawning

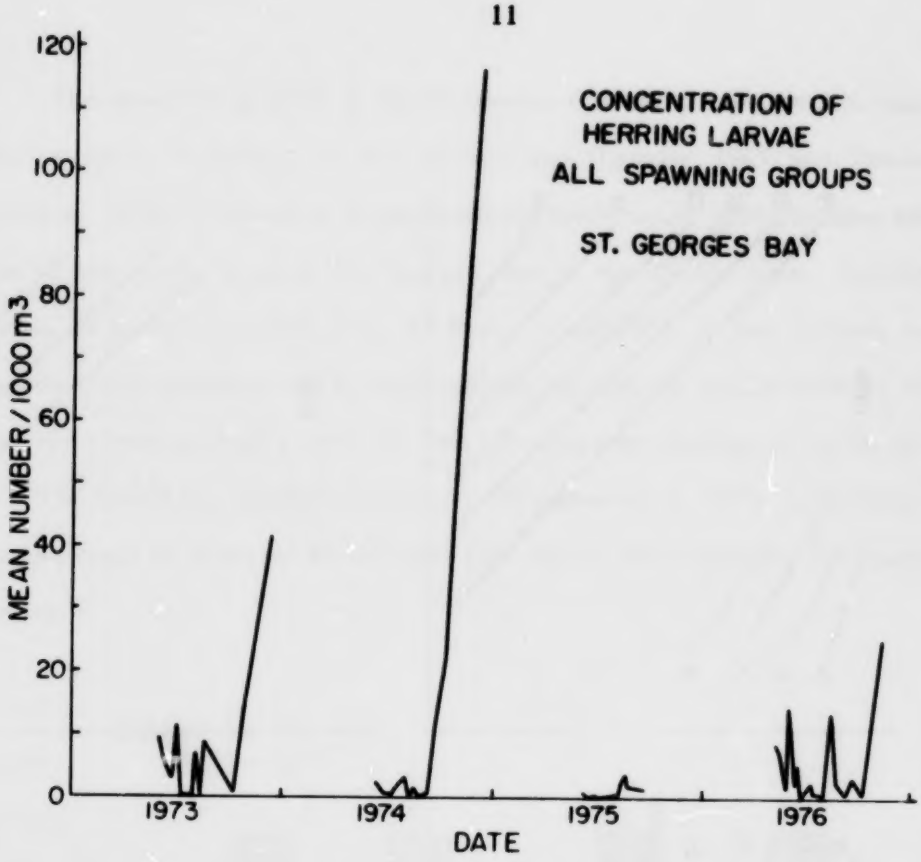
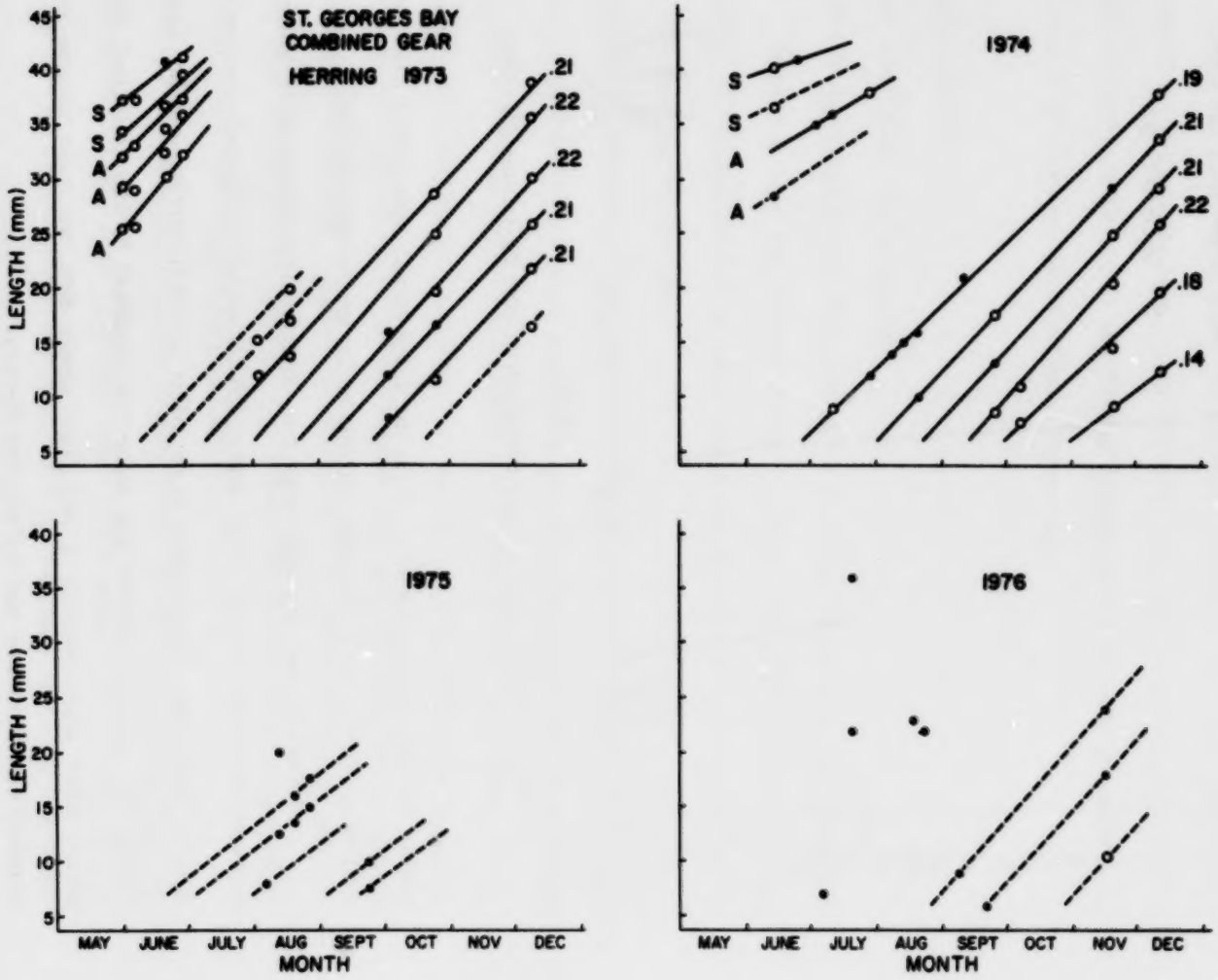


Fig. 6. Mean seasonal concentration of herring larvae (all sizes).

within the bay during the fall. Thus the later larval contingents were assigned to autumn spawning using the same criteria as for spring spawned fish.

However, we are left with two intermediate components which are not represented in the yolk-sac stage and which cannot be attributed to either spring or autumn spawning. Since there is no influx of adult herring into St. Georges Bay during the summer months and since the smallest larvae collected during that period were approximately 9 mm (two weeks old), we must assume they were spawned elsewhere and had drifted into the bay.

Fig. 7. Larval herring cohorts, St. Georges Bay, 1973-1976. Points are mean lengths of component populations. o derived by Harding (1948) analysis, $p < .05$; • $p > .05$ or fitted by eye à la Petersen. Numbers to the right are indicated growth rates (mm/day) for the larval cohorts. S and A are summer and autumn spawned cohorts from the previous year.



The direction of drift in Northumberland Strait is from west to east at a speed of about 7 km/day at the eastern end (Lauzier 1965 and Petrie and Drinkwater 1978). Therefore, a two week old larva would probably have hatched about 80 km to the west of St. Georges Bay in the Pictou area. Landings at Caribou, N.S. 1975 to 1977 (Fig. 8) show, in addition to two autumn runs in September, two spawning runs in summer (late July and the second week of August) which are timed perfectly with the two larval groups showing up in St. Georges Bay. The maximum number of cohorts (8) appeared in 1973; little population structure could be detected in 1975 and 1976 due to low production and inadequate sampling.

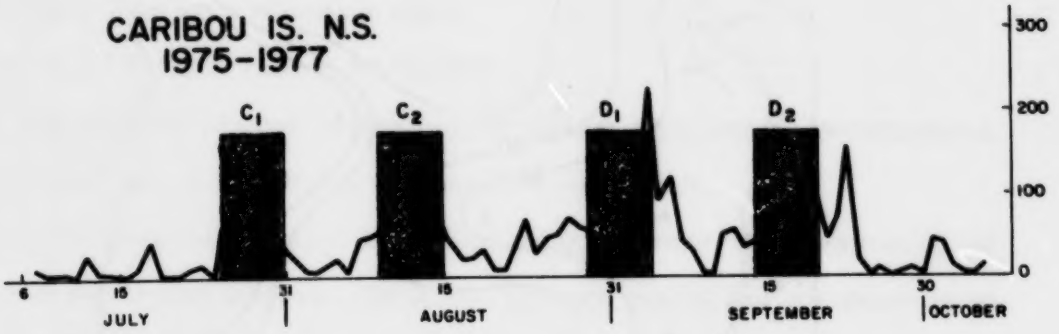


Fig. 8. Mean daily landings (barrels) of herring at Caribou, N.S. From Ware and Henriksen (1978).

During the early part of the sampling season a number of large larvae were captured. These obviously originated from spawning in the previous year. They were assigned to spring, summer or autumn groups on the basis of mean size in December plus length added during the winter at a rate 1/10 that of the summer (Lea, 1919 and Huntsman, 1919).

Distribution

During 1973 and 1974 herring larvae tended to be concentrated in "inshore" waters as opposed to the central portion of the bay (Fig. 9 and Table 3)

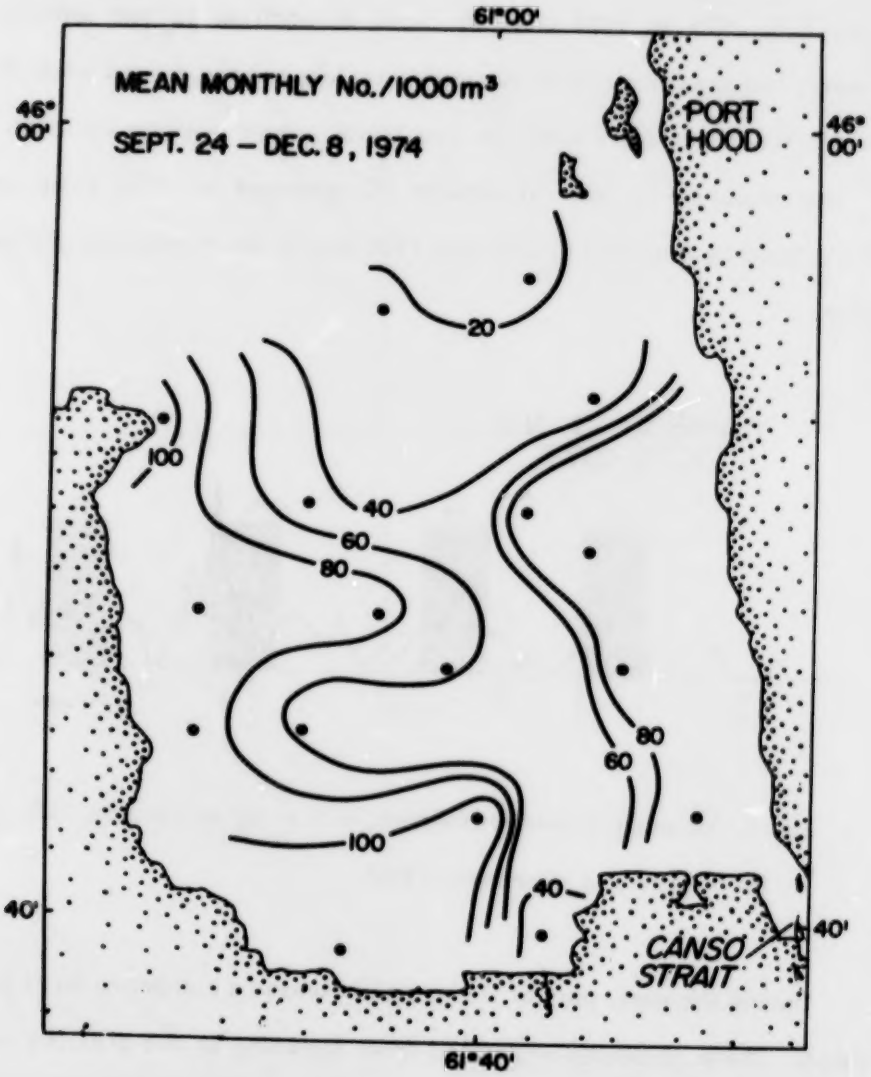


Fig. 9. Distribution of larval herring in St. Georges Bay, autumn 1974.

TABLE 3

Horizontal Distribution of Herring Larvae, St. Georges Bay

Year	Mean Annual Density ($no/1000m^3$) Inshore	Central	% of sample days when inshore density > central density	t statistic	p
1973	5.70	3.97	67	0.99	0.18
1974	26.79	19.74	83	2.14	0.03

* Distance from shore in nautical miles

Inshore 2.3 (0.3-3.9) Central 5.7 (4.0-8.0)

The area adjacent to Cape George had the highest mean annual concentrations, $10.2/1000m^3$ and $29.5/1000m^3$ in 1973 and 1974 respectively.

Sampling horizontally at various depths allowed the construction of vertical distribution profiles. Those for 1974 are typical and are shown as an example (Fig. 10). Larvae occur mainly around 5 m in late spring, rise to near surface during early summer and thereafter are found at increasing depth until by December the mid point of their distribution is approximately 15 m.

For comparison we have plotted the median distribution of larvae over depth during 1973-1976 in St. Georges Bay (Fig. 11). We have also included larval herring found in waters of comparable depth and temperature in the Gulf of Finland (Sjoblom and Parmanne 1978). Median depth values in the latter part of 1973 and 1976 are probably underestimated since they are based on 15 m values

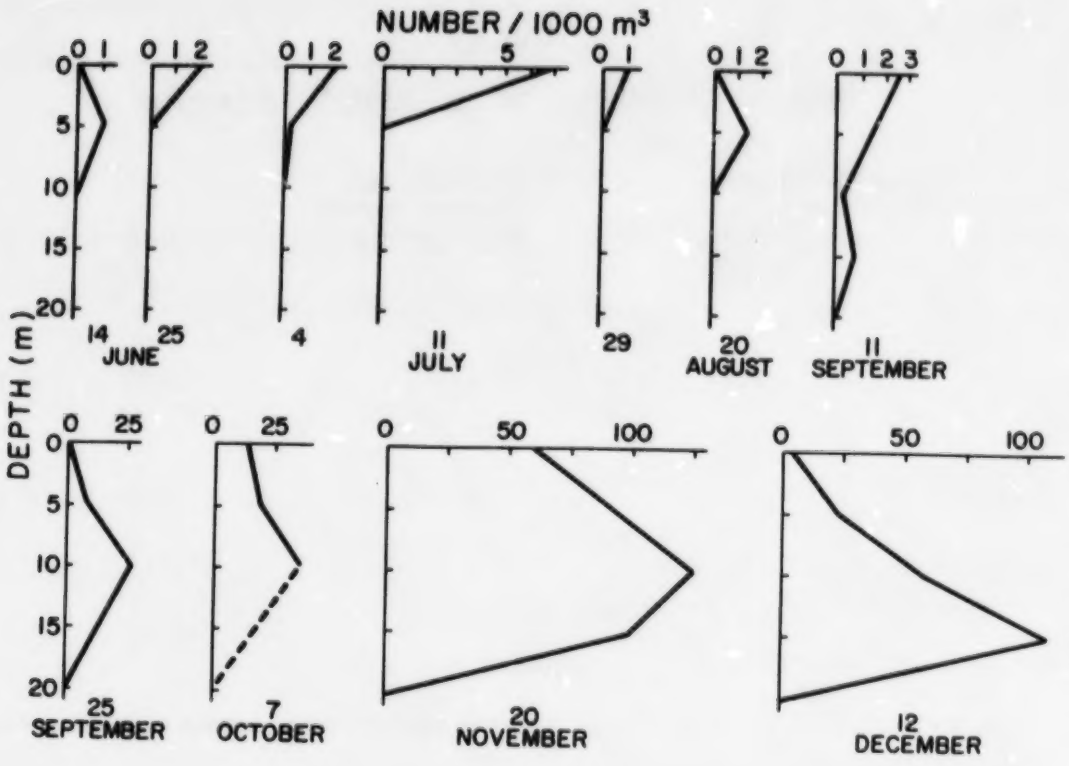


Fig. 10. Distribution over depth of herring larvae in St. Georges Bay, 1974

which were estimated using a linear extrapolation from measured values at 10 m to zero at 20 m. No IKMT was towed in either 1973 or 1976; the majority of herring larvae were taken at depth in the latter part of 1974 by the IKMT.

Relationship to zooplankton

Relationships between herring larvae and zooplankton were examined in the period from September to December, 1974 when larval densities were the highest of all years. Zooplankton data were taken from Lambert et al. (1982).

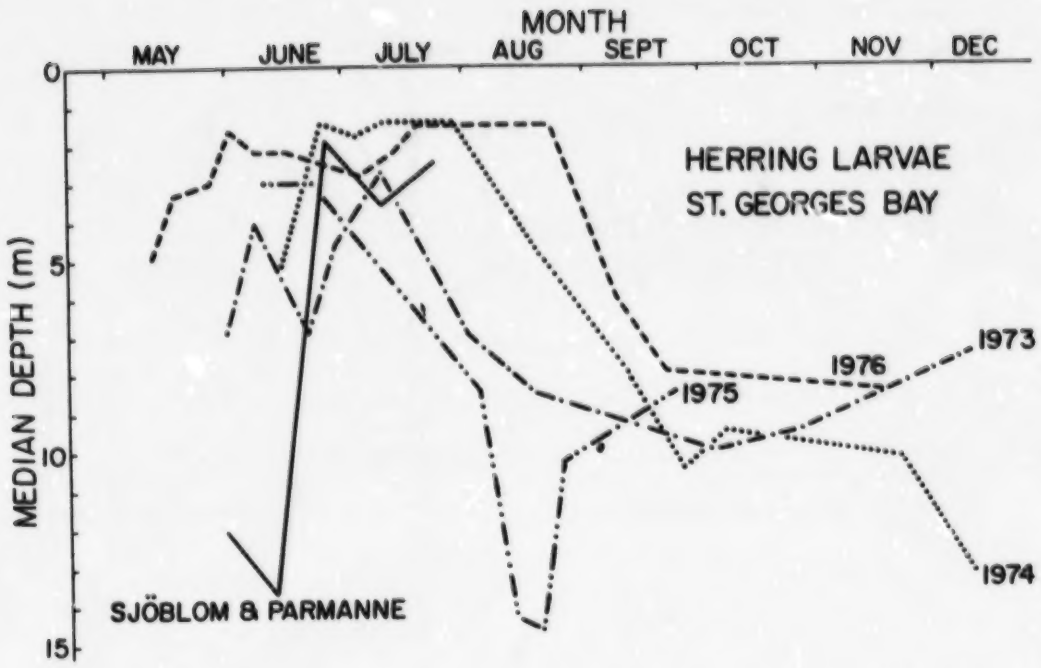


Fig. 11. Median depth of herring larvae in St. Georges Bay, 1973-1976 and Gulf of Finland (Sjöblom and Parmanne 1978).

A linear relationship was found between larval length and mean zooplankton size (Fig 12) and a curvilinear relationship between abundances (Fig. 13). Plotting median depths of the herring and the total zooplankton distributions over time (Fig. 14) provided further evidence of the close coupling between predator and prey. The two distributions generally fluctuate in phase and in fact coincide during most of the autumn. A closer correspondence can be obtained by

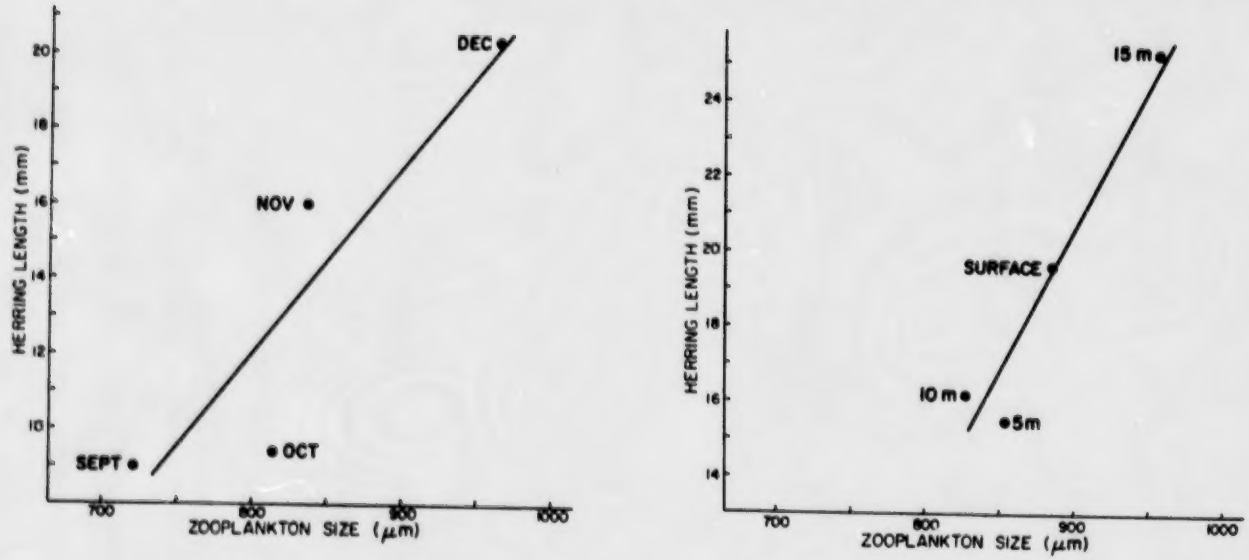


Fig. 12. Relationship between sizes of herring larvae and zooplankton.

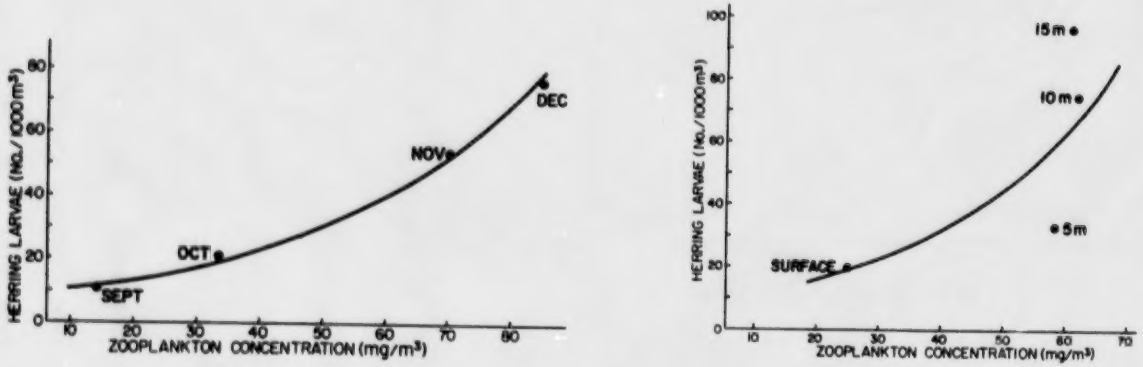


Fig. 13. Relationship between concentrations of herring larvae and zooplankton.

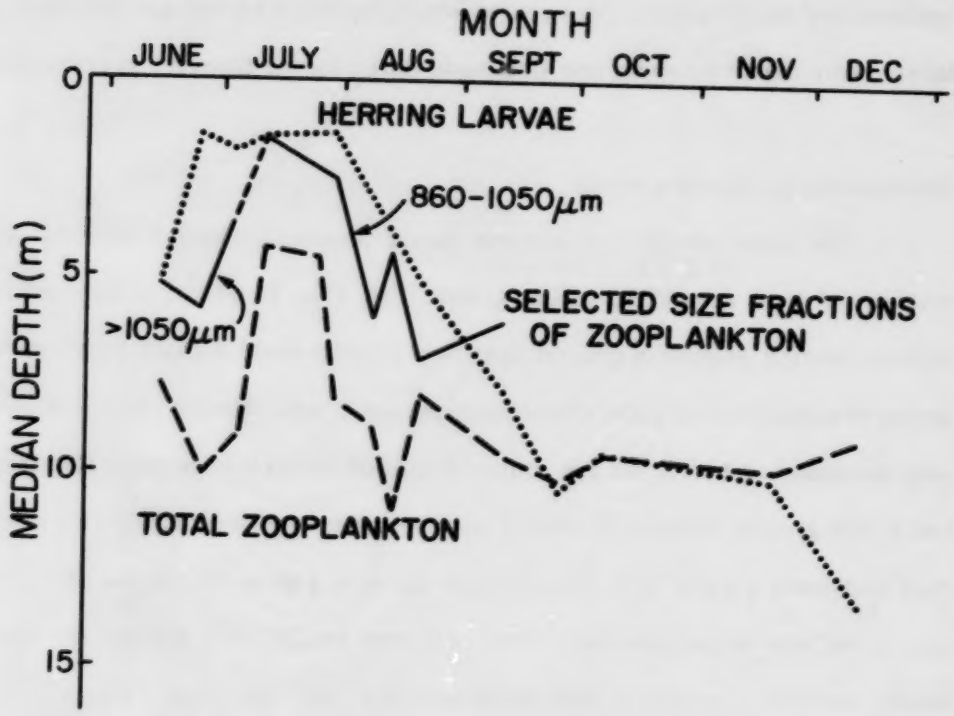


Fig. 14. Seasonal variation in median depth of larval herring, total zooplankton (all sizes) and selected size fractions of zooplankton.

plotting specific size fractions of the zooplankton community. Since larger larvae eat larger particles (Last 1980), it is logical to compare large larvae with large zooplankters. Hence, for example, during June when most larvae were in excess of 30 mm we have plotted median depth of the 1050 μm and 860 μm plankton fractions (upper zooplankton line in Fig. 14). The appropriate zooplankton size fraction was selected using the empircially derived formula describing size

correlation. This size-matching exercise was not continued into the autumn because the larval population became too complex; whereas earlier, most of the larvae were clustered about one size mode (large larvae from the previous year).

Relationship to spawning stock

The mean spring and autumn larval production varied directly with the numbers of their respective parent groups (Fig. 15). However, it seemed that the autumn herring enjoyed a greater spawning success since a much higher number of larvae resulted from a generally smaller parent group. Messieh (1976) showed that autumn-spawning herring in the southern Gulf of St. Lawrence were 10% larger and had a 50% greater relative fecundity than spring-spawning herring. This would lead to a relatively greater egg deposition by autumn spawners. On the other hand, he also noted that spring spawners matured a year earlier than autumn spawners; this would partially counteract the increased size and fecundity factors. Although deposition of eggs by autumn spawners is no doubt greater than that of spring spawners (perhaps almost double), the difference is not great enough to account for the approximately 20 fold difference in larval production.

We had hoped to investigate possible differential mortalities in spring and autumn spawning beds but were unable to locate any spawning concentrations; no doubt due to the extremely low levels of spawning stock.

The densities of summer larvae in St. Georges Bay were about equal to those of spring larvae. However, it should be remembered that these summer larvae are but a fraction of the total production originating about 80 km distant near Pictou. What this fraction is and whether it varies annually is difficult to say, but we can make a rough estimate.

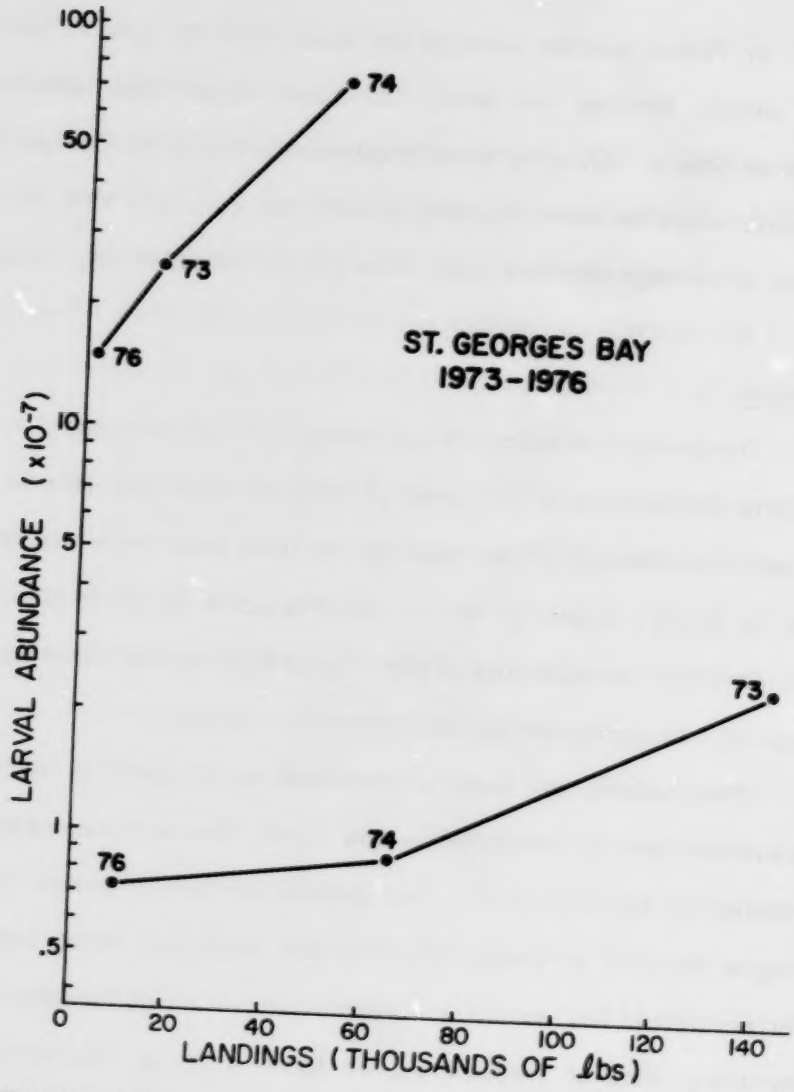


Fig. 15. Relationship between annual abundance of herring larvae and their parent stock. Lower trace - spring stock; upper trace - autumn stock.

Our argument supposes that egg production in summer and autumn groups is proportional to landings (spawning stock), and that subsequent survival is constant.

At Pictou summer landings are about 70% the size of autumn landings. These autumn landings are about 100 times larger than autumn landings in Antigonish county. Knowing larval production levels in St. Georges Bay and using the relationships between spawning groups, we calculate that St. Georges Bay received on average over four years 0.2% ±0.1 of Pictou summer larval production.

Discussion

The conclusions reached here, in regard to the complexity of the population structure, are essentially the same as those of Ware and Henriksen (1978). In addition to corroborating their findings, we have shown that the peaks in landings of herring during a spawning run correspond to actual spawning pulses. Further, we can demonstrate the existence of eight larval contingents; three originating during late spring, two during summer and three in the autumn.

Observations on vertical distribution of herring larvae are often contradictory (see review by Seliverstov 1974). The seasonal median of the depth distribution of herring larvae in St. Georges Bay is very similar to that of Baltic herring in the Gulf of Finland (Sjoblom and Parmanne 1978); but whereas these researchers could not associate vertical distribution of larvae with either water temperature, wind or zooplankton, we found a strong relationship between the distribution of larvae and zooplankton. In addition, we found good correlation between abundance of larvae and zooplankton and also size of larvae and zooplankton.

CAPELIN ADULTS

Occurrence in St. Georges Bay, N.S.

Capelin were unknown in St. Georges Bay before 1975; in fact they they were not recognized by many of the older fishermen. Numbers peaked in 1977; but since 1978, when a few were observed, no capelin have been reported in the area.

1975. Capelin were taken in trap nets at Ballantynes Cove during the last week in May. They moved into the bay at least as far as Cribbean Head where eggs were reported on nets. Schools were not seen in the area after mid-June.

1976. On May 26 large numbers of capelin entered the bay; many were caught at Ballantynes Cove. For example, 2000 lbs were removed from one trap and still more dead remained in the bottom. After hauling, a quantity of spawn was found smeared in the boat. Much schooling activity was noticed by local fishermen who also reported beach spawning and deposition of eggs on lobster gear between Livingstone Point and Cape George (see Fig. 3 for orientation). On May 31 we found newly-spawned capelin eggs in pockets of sand on the coarse gravel and boulder beach just north of Ballantynes Cove. These eggs had disappeared by June 15, no doubt having hatched. We estimated the peak of spawning to be between May 25 and June 15; the surface water temperature during this time ranged from 6.5 to 6.9 C.

1977. The first capelin arrived at Ballantynes Cove on May 5. On May 11 traps here were heavily loaded; no spawning activity had been reported as yet. Moderate numbers of capelin were taken during the next two weeks; enough to be annoying to the local fishermen as there was no market for this fish. During the last half of May the surface water temperature rose rapidly from 4.2 to 11.4°C by May 24 when another huge wave of capelin again filled Ballantynes Cove trap nets to capacity. These fish were very ripe but still no spawning had been reported. On

May 28 there was a bad storm and surface temperature on May 30 was down to 7.5 C. We undertook a beach survey on May 31 from Ballantynes Cove around Cape George and west to Livingstone Point. There were no eggs between Ballantynes Cove and Cape George; a thick patch just beyond the Cape, and then light spawn the remaining distance to Livingstone Point. The survey was continued on June 1, but no eggs were found on beaches between Livingstone Point and Lismore. Many capelin were sighted at Margaree Harbour, Inverness County, on June 10; however, no spawning had been noticed. June 15, capelin began beach spawning at Margaree Harbour. At Ballantynes Cove, June 16, a trap net sample of 400 fish comprised all males. Capelin were still abundant around Cape George and a pest to fishermen up to June 21; thereafter, numbers diminished rapidly and by the end of the month the capelin had gone for the year throughout the area.

Population Structure

On three occasions a sample of about 50 fish was taken randomly from traps at Ballantynes Cove. Our data revealed that males predominated, that the largest fish arrived first and there was a decrease in size as the season progressed (Fig. 16, Table 4). These findings were the same as those of Templeman (1948) who explained the disportionate nearshore sex ratio by the fact that females tend to congregate offshore and then in small groups make spawning forays to the beach where the males are in constant attendance.

Data from all samples were combined but segregated on the basis of sex and the totals subjected to the population analysis described in earlier sections. The size-frequency curves of males and females comprised three and four components respectively. These components were ascribed age categories on the basis of comparison to age-at-length data of Templeman (1948) and Olsen (1968)

and by the fact that the predominant age group in spawning schools is generally three-year-olds (Jangaard 1974), (Table 5).

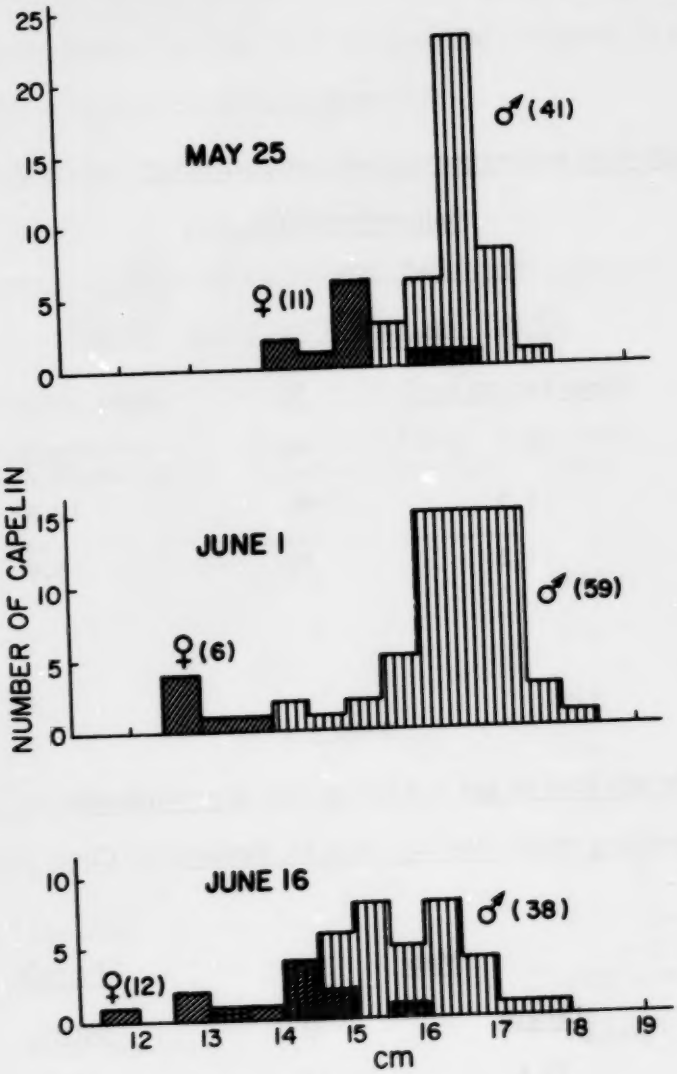


Fig. 16. Size frequency histograms of adult capelin St. Georges Bay 1977.

More males than females die from the effects of spawning (Templeman 1948); this was reflected in our data in that very few four-year old and no 5 year-

old males were found. These data also point out the differential growth rate between males and females; this divergence in size becomes established by the second year (Jangaard 1974).

TABLE 4

Mean length (cm) and percentage sex composition of capelin spawning stock Ballantynes Cove, N.S.

Date	Males		Females	
	Mean Length (cm)	%	Mean Length (cm)	%
May 25	16.7	79	15.0	21
June 1	16.5	91	12.8*	9
June 16	15.2	76	13.6	24

* 6 fish only

TABLE 5

Mean length (cm) at age and percentage age distribution of capelin spawning stock; May 25 - June 16, Ballantynes Cove, N.S.

Age	Male		Female	
	Length	%	Length	%
2	14.8	17	12.3	24
3	16.4	78	13.9	35
4	17.8	5	14.9	31
5			16.1	10

Beach spawning survey

In 1977, as previously mentioned, beaches in the Cape George area were examined for capelin spawn (Fig. 17). With the exception of beach A, spawn, if not absent, was present only in small amounts (Table 6).

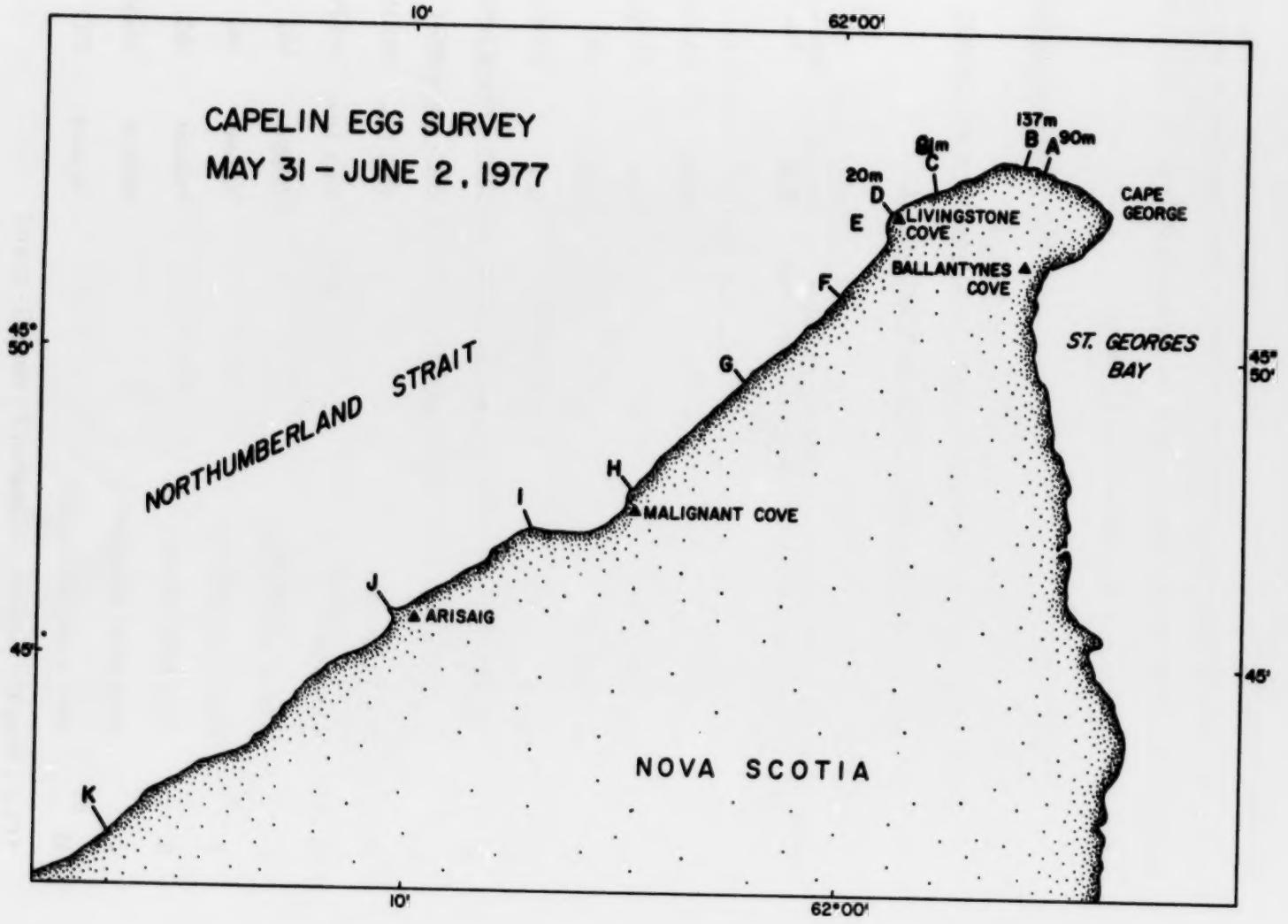
TABLE 6

Extent of capelin beach spawning between Ballantynes Cove and Lismore May 31 - June 2, 1977. (see also Fig. 17).

Beach	Patch Dimensions Length x Width (m)	Distance of Upper Boundary from High Tide	Density Eggs	Substrate Type*
A	90 x 8	1	Heavy	CS-FG
B	22 x 2.5	2	Low	CS
C	60 x 3.5	2	Low	CS
D	20 x 3	2.5	Low	CS-FG
E	117 x 3	3	Low	CS-FG
F	41 x 4.6	4.5	Low	FG-CS
G	20 x 3 (Approx.)	-	Very Low	FG-MG
H	Scattered	-	Very Low	MS-FG
I	Many small beaches		Absent	MG
J	Many small beaches		Absent	MG
K	Many small beaches		Absent	MG
L	Many small beaches		Absent	Rocky
M	Many small beaches		Absent	FS

*Fine - fine; M - medium; C - coarse; S - sand; G - gravel

Fig. 17. Sites examined for evidence of capelin spawning.



Beach A, where spawn was the heaviest, was surveyed in detail. Samples were taken along a transect from high tide mark down to the water (about ½ tide at time of survey). A coring type device (15.2cm x 15.1 cm and 10.1 cm deep) was used at four locations along this transect. This instrument allowed the division of the "core" into three sections each 3.3 cm thick at 1.6, 4.9 and 8.2 cm depth respectively. Such a three piece section could not be obtained at the lowest station since the substrate was very thin and overlying bedrock.

This beach surface was quite irregular and broken by large boulders; small to medium sized boulders extended from below low water up to about half-tide level. Above these boulders the beach consisted of coarse sand and fine gravel. Although capelin eggs extended from a point one metre below high tide mark down to the water line they were most numerous four to eight metres below high tide mark; indeed, in this area the beach was actually spongy to walk on. The egg patch ended abruptly at each end of the beach where the substrate gave way to coarse gravel and large rocks. The sea bottom was examined by SCUBA from the half-tide level on the beach where spawn ended, out about 60 metres to 8 metre water depth. The bottom was rocky with patches of sand; no spawn could be located.

The data (Table 7) indicated two density gradients of eggs: low to high from the high tide mark downwards and high to low from the substrate surface downwards (Fig. 18). The percentage of dead eggs was high in the upper regions of the beach but low nearer the water. However, there appeared to be no difference in the ratio of live to dead eggs between the surface and deeper layers of the substrate.

Table 7

Capelin Spawning Survey, Beach A, Cape George, N.S.

Site	Distance from High Tide (m)	Sample Depth (cm)	Egg Density no/ml	Dead Eggs (%)
1A	7.5	3	254	5.7
1B	7.5	3	225	5.3
2A	7.2	3.4	196	-
2B	7.2	3.4	241	-
3A	3.5	3	142	11.9
3B	3.5	3	123	20.8
3C	3.5	6	43	8.6
3D	3.5	6	53	14.0
3E	3.5	9	4.6	1.3
3F	3.5	9	3.2	36.1
4A	1.0	3	.5	41.7
4B	1.0	3	.2	100.0
4C	1.0	3	.5	66.7
4D	1.0	3	.4	100.0
4E	1.0	9	0	-

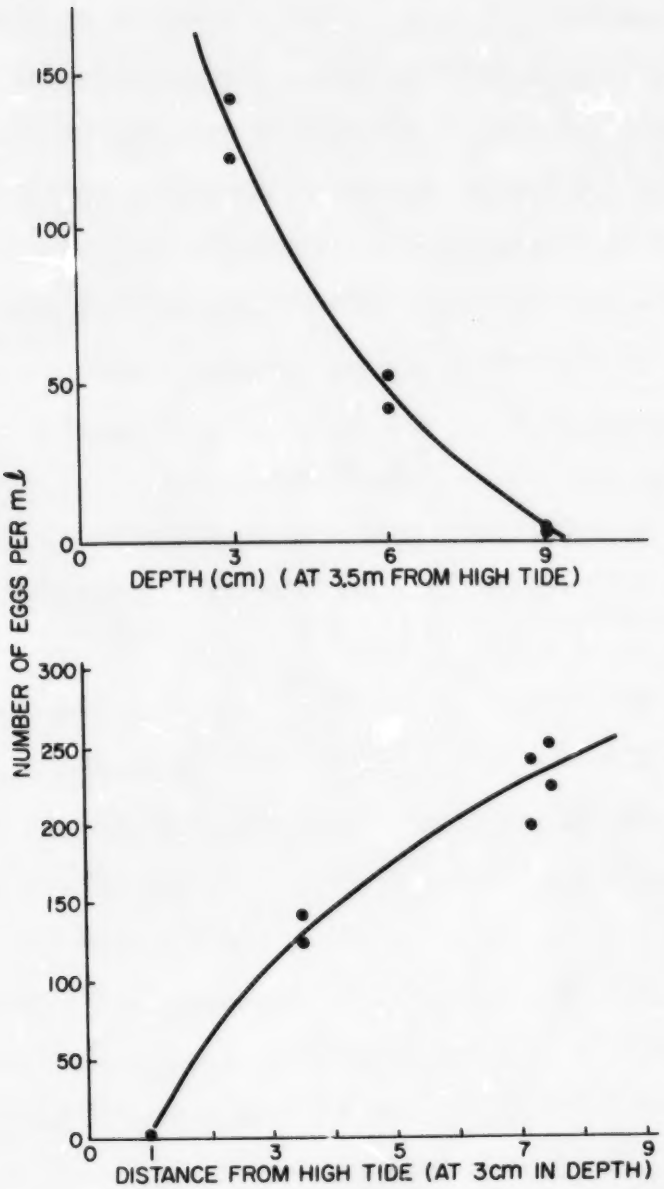


Fig. 18. Density of capelin eggs from core samples, Beach A, Cape George, 1977.

An attempt was made to estimate the number of spawning adults from the amount of eggs deposited. This estimate was rough since measurements of egg density were made on beach A alone and remaining beaches were subjectively compared to it. In addition, the depth of deposition within the substrate was assumed to be the same for all beaches. From the number of eggs (Table 8) and fecundity and length-weight relationships (Templeman 1948) and assuming a 1:1 sex ratio, the total number of capelin adults was calculated as 18.2×10^5 (5.1×10^4 lbs -male; 3.4×10^4 lbs - female).

TABLE 8

Extent of capelin beach spawning in Cape George region

Beach	Dimensions of patch (m)	Area of patch (m^2)	Eggs/m^2 ($\times 10^6$)	Total eggs ($\times 10^6$)
A	90 x 8	72	45.6	3286
B	22 x 2.5	55	20	1100
C	60 x 3.5	210	20	4200
D	20 x 3	60	20	1200
E	117 x 3	351	20	7020
F	41 x 4.6	190	20	3800
G	20 x 3	60	5	300
H	scattered	10	5	50
				20956

Number of eggs/female (15cm)*	23000
Number of females	9.1×10^5
Total number of capelin	18.2×10^5
Weight of males (16.7 cm) = $9.1 \times 10^5 \times .061$ lbs*	5.1×10^4 lbs
Weight of females (15cm) = $9.1 \times 10^5 \times .041$ lbs*	3.4×10^4 lbs

* after Templeman 1948

Hatching time of capelin in 1975 and 1976 was obtained from population analysis (next section). Incubation time at 7°C is about 20 days (Frank & Leggett 1981). Thus we estimate over 90% of capelin eggs had been deposited by the end of May in both years. Furthermore, after speaking with fishermen we concluded there was no fresh influx of capelin after June 1 in 1977, and also that there was no beach spawning in St. Georges Bay other than the Cape George area. Therefore, it is probable our beach survey accounted for the bulk of capelin egg deposition.

Adding 5% to account for possible spawning after June 1 we arrive at a figure of 90,000 lbs of capelin spawning stock. Most 2 year old fish are immature (Jangaard 1974) and they represented over the season about 20% of the population (see Table 5). Therefore we estimate about 108,000 lbs of capelin entered St. Georges Bay in 1977.

CAPELIN LARVAE

Abundance and population structure

There was a increase in abundance from 1973-1976, with numbers in the last year an order of magnitude greater than preceeding years. The peak was always during the last week of June (Fig. 19). As in the case of herring, length frequency histograms revealed polymodality in the larval capelin populations; these were analysed as in previous sections of this report and resolved into seven and six components in 1976 and 1975 respectively (Fig. 20).

With few exceptions, the component populations were represented in the 5mm length class, indicating an in or near St. Georges Bay origin. Those with no representation in the small size categories were probably immigrants and comprised a mere 1% and 3% of all larvae collected in 1976 and 1975 respectively.

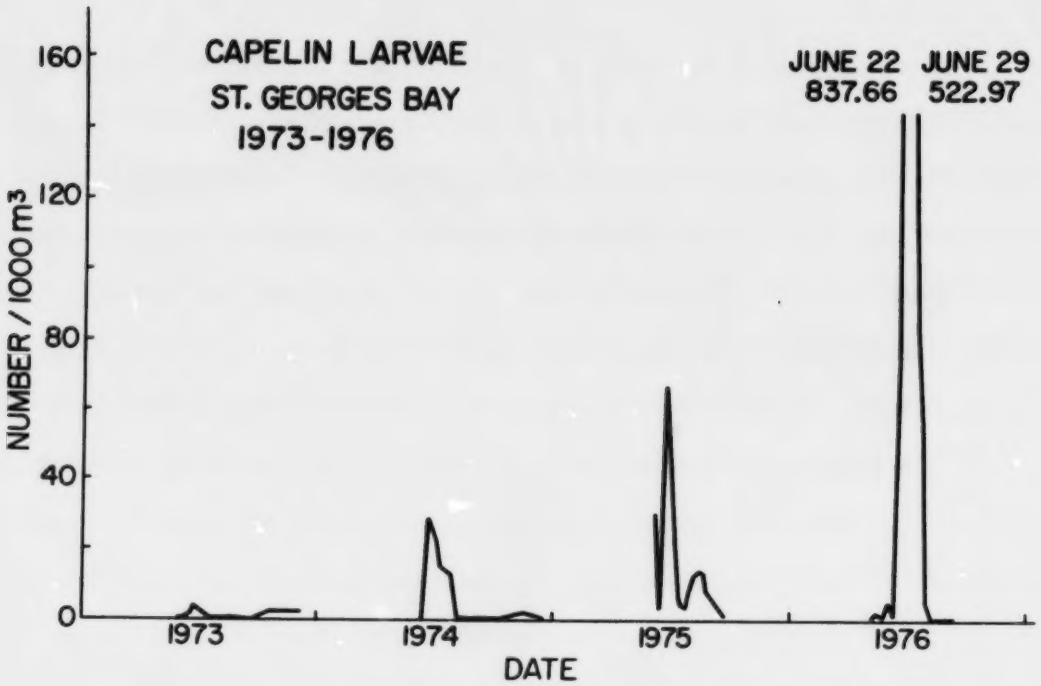


Fig. 19. Annual abundance of capelin larvae, St. Georges Bay.

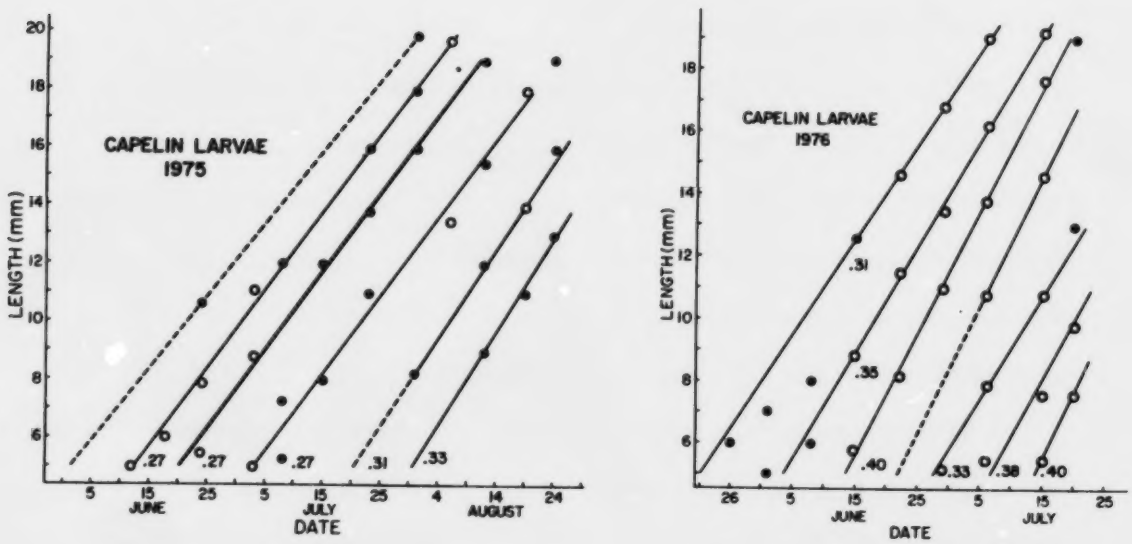


Fig. 20. Larval capelin cohorts, St. Georges Bay 1975-1976.

Notation same as Fig. 7

The indicated growth rate for 1976 was .35mm/day (SD .04), and for 1975, .29mm/day (SD .03). Large capelin larvae collected in June of 1976 were no doubt yearlings (growth curve - Fig. 12 in Jangaard 1974, after Dragesund et al. 1973). Their growth rate over one year was reconstructed in Fig. 21. Isolated larvae fit well within the interpolated growth "range". (Sept. 1975 - 1 larva; Nov. and Dec. 1974 - mean of 10 and 4 larvae respectively). The apparent overwintering growth rate was .04mm/day which compares well with the 10:1/summer:winter ratio for herring larvae.

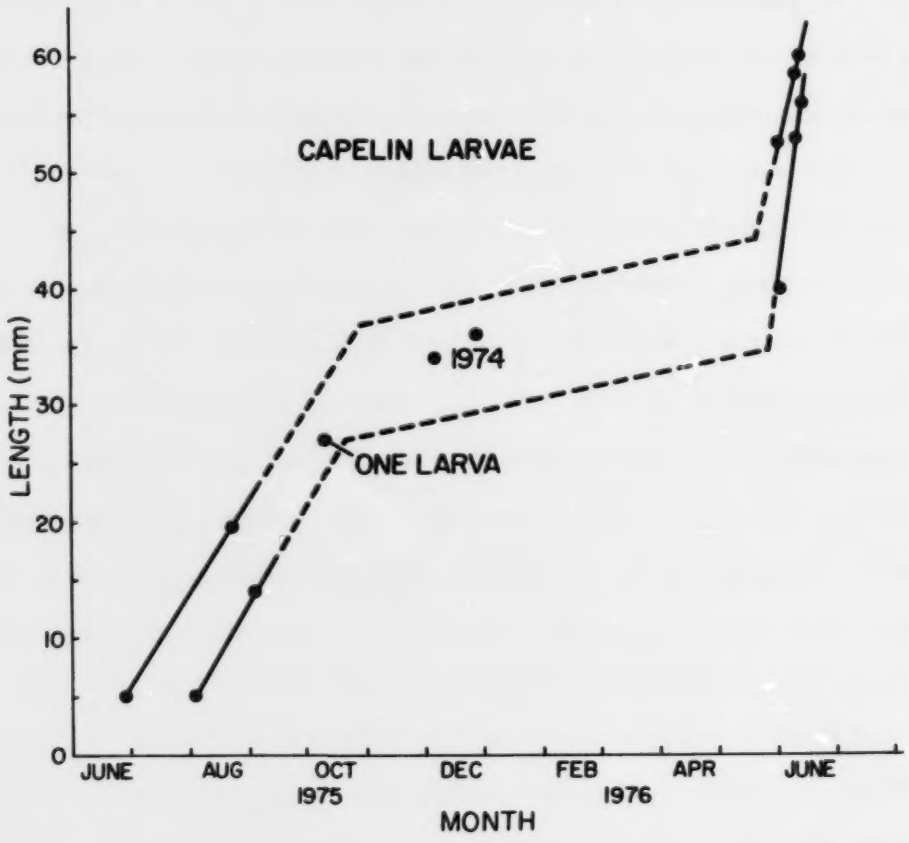


Fig. 21. Growth of capelin larvae during the first year of life, St. Georges Bay.

Larval Emergence

Frank and Leggett (1981) demonstrated that capelin larvae exited the beach gravel in concentrated batches rather than continuously, and that these emergences were predictably linked to the occurrence of onshore winds. Further, it was shown (Frank and Leggett 1982) that these onshore winds induced changes in the nearshore environment causing it to be dominated by warmer less saline water masses which contained fewer predators and more food. Thus the timing of the entry of larvae into the pelagic environment is clearly adaptive.

We examined our data in light of these findings to see if the relationships still held at the geographical limit of the spawning range; in fact at a location where capelin occurrence, let alone spawning, had never before been reported.

Our data support Frank and Leggetts' hypothesis of wind-induced larval emergence. Larval cohorts (Fig. 20) were back extrapolated to 5mm which is length at hatching. These estimated dates of hatching were compared to the wind record (from East Baltic, P.E.I. - best indicator for St. Georges Bay; K. Drinkwater, Marine Ecology Lab - personal communication) and a close correspondence was found with onshore winds, (Fig. 22, and Table 9). In this case winds from between N and SE were considered onshore. Onshore winds always occurred during or shortly before estimated larval emergence. Mean speed of onshore winds during the period 2 days before to 2 days after larval emergence was 12.3 knots in both 1975 and 1976 (Table 10).

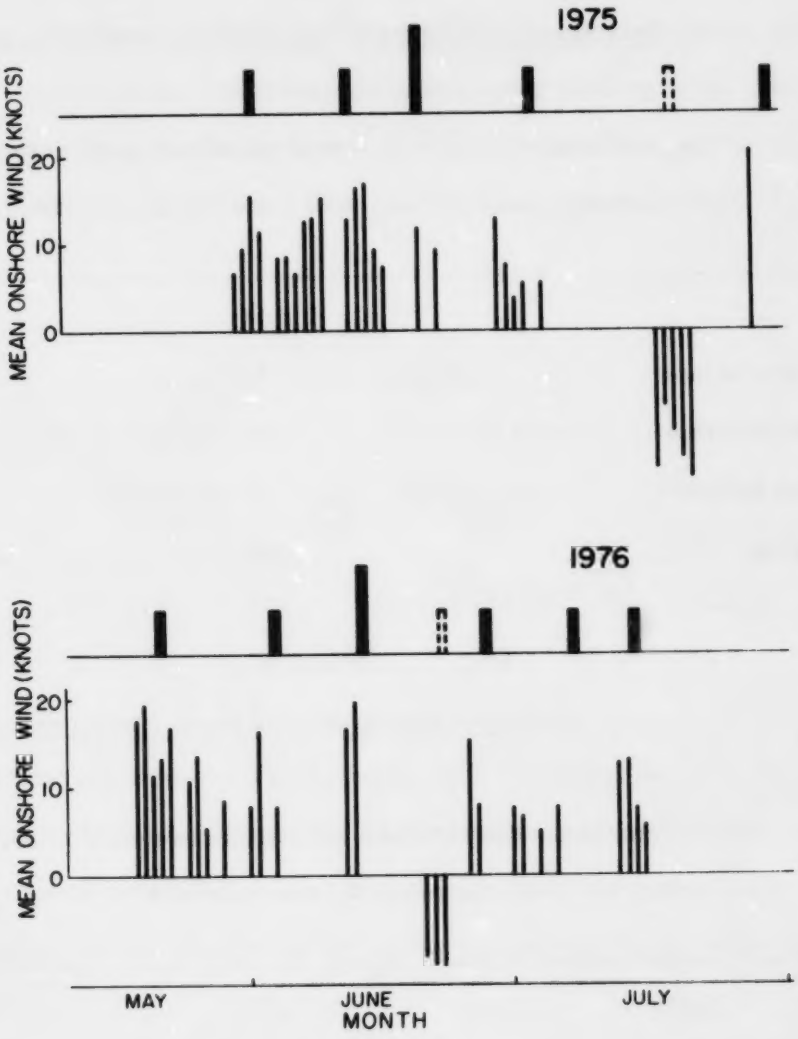


Fig. 22. Relationship of larval capelin emergence to onshore winds. Black bars are larval cohorts, tallest is the major cohort, dotted bar is larval cohort probably originating on south shore of Pictou Island. Lines below base of wind scale are winds from southerly direction.

TABLE 9

Relationship of onshore winds to larval capelin emergence

Onshore wind occurrence	% of total # of larval cohorts emerging in relation to onshore winds	
	1975	1976
3 days before	0	0
2 days before	17	14
1 day before	17	43
During	66	43

TABLE 10

Average wind speed associated with larval capelin emergence

Maximum daily onshore wind within two days of larval emergence (% occurrence)		
Knots	1975	1976
< 10	17	14
10-15	67	29
> 15	50	57

One larval contingent in both 1975 and 1976 was not associated with onshore winds at Cape George; southwesterly winds were blowing when these contingents emerged. Since neither larval group was represented in or near yolk sac stage we assumed their origin was not in or near St. Georges Bay.

TABLE 11

Immigrant capelin cohorts

Year	Size at first occurrence in St. Georges Bay	Growth Rate (mm/day)	Days since hatching
1975	8.2	.31	10.3
1976	10.8	.42	13.8

Surface drift time from the Pictou region to St. Georges Bay is about 12 days (see section on larval herring - summer cohorts) which is the approximate age of the immigrant capelin larvae (Table 11). Thus we can place the probable site of spawning for these particular capelin on the southerly shore of Pictou Island (see Fig. 1 for location).

Distribution

The size distribution of capelin larvae strongly indicates the northwest shores of St. Georges Bay as their origin. In all years the smallest larvae were taken at station 9 off Cape George. In addition the coefficient of variation in size ($s/\bar{x}$) was always lowest in the same region.

About three weeks after they first appeared in the plankton capelin larvae were more or less evenly distributed around the bay. However, capelin showed definite depth preferences. The seasonal change of median depth was similar to that of herring in that the majority of larvae were near the surface initially but were found progressively deeper with time (Figs. 23 & 24).

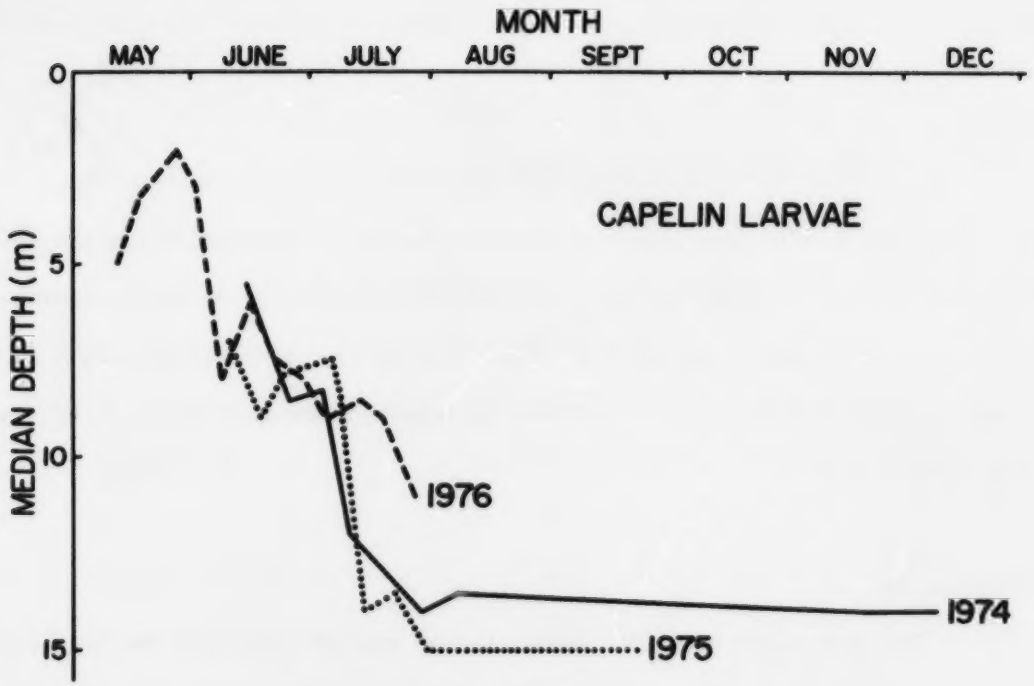


Fig. 23. Seasonal variation in median depth of capelin larvae, St. Georges Bay, 1974-1976.

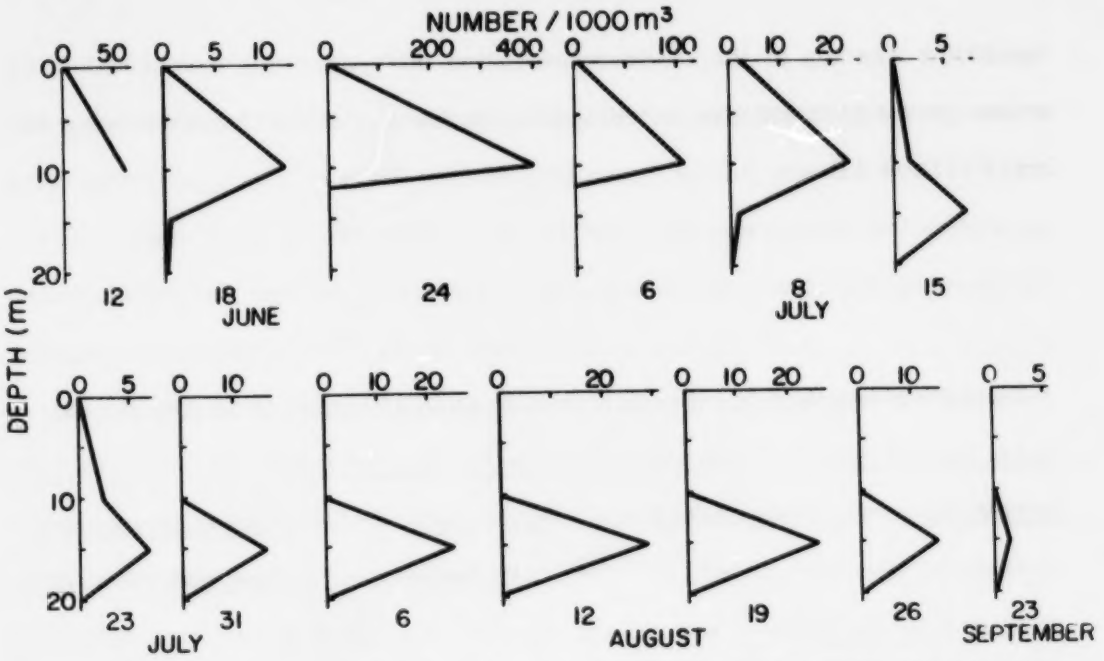


Fig. 24. Seasonal distribution over depth of larval capelin, St. Georges Bay, 1975.

Clockwise Gyre

The deposition of capelin spawn at one location in St. Georges Bay allowed us to test the gyre hypothesis of Petrie & Drinkwater (1978). Knowing the capelin growth rate and using various drift velocities in an iterative manner it was possible to calculate theoretical size at specified distances from the point source. The major cohort of 1976, released from beach gravel on June 13, was used for this exercise. The starting point of the pelagic drift phase was considered to be station 9 (approx. 1 mile off Cape George) on June 15. Both clockwise and anticlockwise drifts were tested at speeds from 5-15 cm/sec. One circuit of St. Georges Bay was estimated to be 45 nautical miles. Larval growth rate was 0.4 mm/day.

Theoretical larval size was compared to actual larval size at the location specified by any given drift rate. None of the anticlockwise iterations was

significant whereas in the clockwise direction drift velocities from 10.75-11.25 cm/sec gave significant size matching (5% sig. level) with 10.75 cm/sec being the best fit (Table 12).

TABLE 12

Theoretical length of larval capelin drifting at 10.75 cm/sec in St. Georges Bay

Sample Date	Days Adrift	Naut. miles Drifted	Size of larvae (mm)	
			Expected	Actual
June 13	Hatch	-	5.0	-
June 15	0	0	5.8	6.0
June 22	7	35.1	8.6	8.8
June 29	14	70.2	11.4	12.1
July 6	21	105.3	14.2	14.1

Recirculation was indicated as the larval cohort could be followed for 2.3 circuits of the bay.

Discussion

Capelin are an arctic-boreal species whose distribution tends to change according to fluctuations in cold water masses such as the Labrador current. Preferred temperature for spawning is slightly higher than that which determines the geographical range (Templeman 1968). Beach spawning occurs along Labrador and Newfoundland coasts at water temperatures of 5.5-8.5°C. Temperature

conditions in St. Georges Bay up to the end of June at least, are well within the range tolerated by capelin. However, during the period 1975-1977 when capelin were abundant, there was no obvious difference in the thermal regime from previous years so it is not clear what initiated this uncommon occurrence of capelin. However, such an occurrence is not unprecedented since Huntsman quoted in Bigelow & Shroeder (1953) says of capelin

"In the Gulf of St. Lawrence it occurs abundantly in limited areas, which shift somewhat from year to year. It occurs periodically in similar limited areas farther south. The southeastern corner of Cape Breton is the center of such an area, where large quantities were taken in 1917. Halifax is the center of another area, where, however, it is more rare. In 1916 it was abundant at Sambro, near Halifax. The next area is in the Bay of Fundy, where they have, exceptionally, been taken in large quantities at long intervals."

Within the Gulf of St. Lawrence spawning is common along the north shore, St. Lawrence estuary around the Gaspe peninsula through the Bay of Chaleur down to the Miramichi estuary (Jacquaz et al. 1977, Parent and Brunel 1976). Spawning is extremely rare in the south and southeast of the Gulf. Cox (1921) collected one specimen of Mallotus villosus at Cheticamp, Cape Breton in 1917 and also reports the species as being rare in the Magdalens. Fishermen in the Magdalen Islands reported capelin appeared there in 1975 after an absence of 35 years. During the 1975-1977 period capelin were reported along the west coast of Cape Breton and south as far as Pictou.

Outside the Gulf of St. Lawrence capelin have occurred sporadically as far south as the Gulf of Maine. We have collected capelin larvae in Bedford Basin, Halifax. On December 23, 1975 larvae of mean length 44 mm were captured at 5 metres; and again in 1977, mean length 39mm, on March 11 at 3 metres and April

13 near the surface.

Two specimens 50mm long were taken at 10 m in Cumberland Basin, Bay of Fundy on March 30, 1982 (N. Prouse, Marine Ecology Lab - personal communication).

The advent of capelin to the region had a noticeable effect on other fisheries. Stomachs of cod and white hake captured at Margaree, Inverness and Cheticamp contained capelin. Cod were reported more plentiful at Port Hood, N.S. and Cap aux Meules, Magdalen Islands. Capelin were also found in stomachs of mackerel and salmon at Ballantynes Cove, N.S. and the latter occurred in greater numbers than in the recent past. Lobster catch was down in the Ballantynes Cove area; fishermen there believe lobster eat herring spawn and thus probably capelin spawn as well, in which case they are less likely to be attracted to bait in traps.

GENERAL DISCUSSION

One might expect larval capelin and herring, being of similar size and morphology, to be serious competitors for food. However, an examination of depth and size distribution data of both species (Fig. 25) seems to show this is not so. Whenever capelin and herring occur at the same depth they are rarely the same size and vice versa, whenever they are similar in size they rarely occur at the same depth (Table 13). Of course this analysis does not take into account horizontal variability in distributions which would further decrease the likelihood of same size and site occurrence.

TABLE 13

Depth and length coincidence of larval herring and capelin

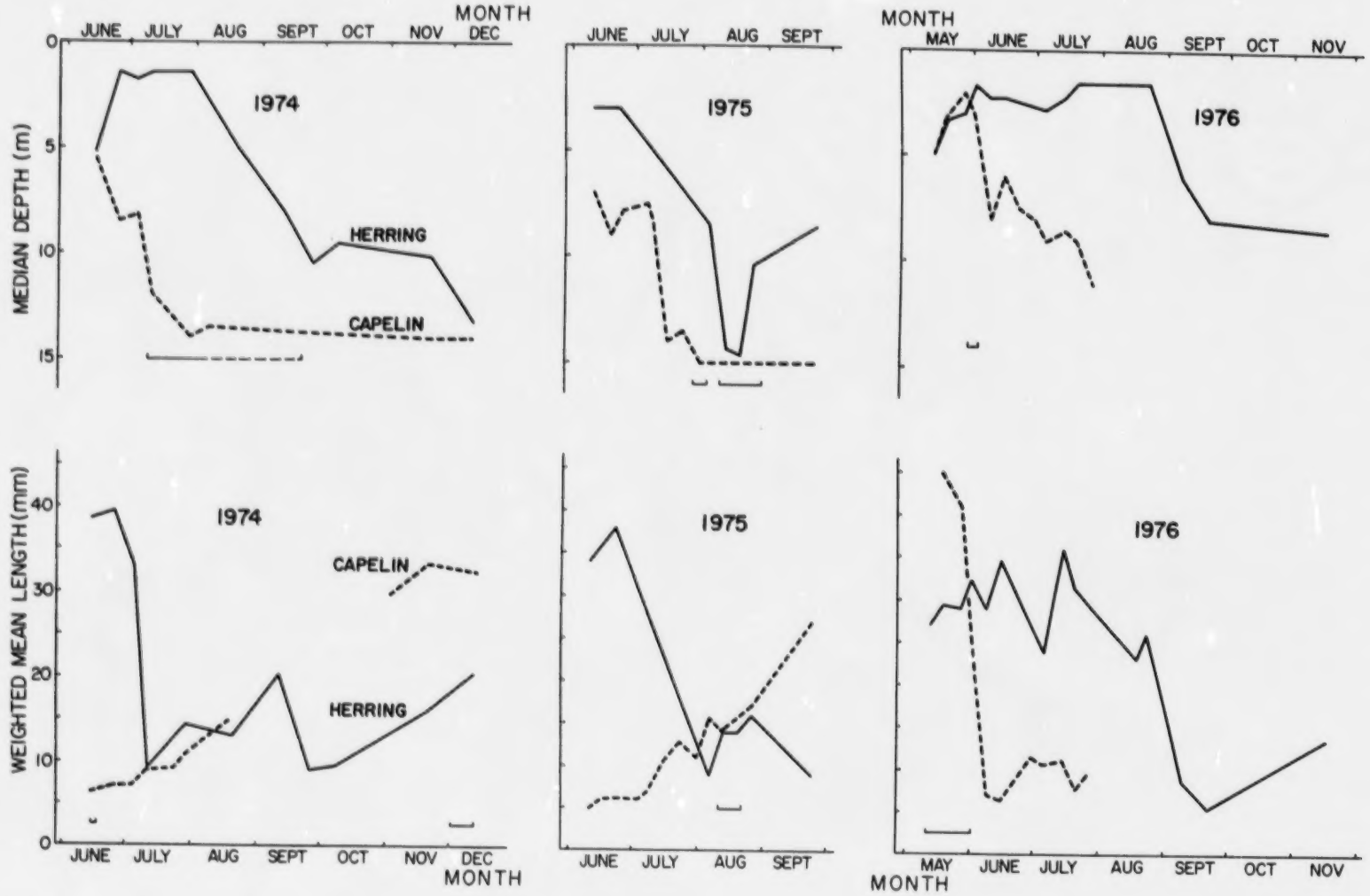
(in days)

Year	Same Length*	Same Depth**	Synonymous length & depth Occurrence	Total days larvae Present	Synonymous occurence as % of total
1976	5	22	4	188	2
1975	27	11	11	105	10
1974	30-73	14	0	178	0

*less than 25% difference

**within 2 metres

Fig. 25. Seasonal variation in median depth and mean length of herring and capelin larvae. Bracketed lines on depth profiles indicate occurrence of larvae of the same size as shown on graph below. Bracketed lines on size plots indicate occurrence of larvae at the same depth as shown on graph above. See Table 13 for size and depth limits.



The fairly regular release of successive cohorts of larvae by both capelin and herring is thought to be a "hedged bet" spawning strategy which helps ensure the survival of slow growing larvae (Lambert and Ware 1982).

The spacing of the cohorts is interesting. Jones & Hall (1974) postulated that this separation is determined by a "feeding range" which is defined by the mouth size of larvae. Briefly, a new cohort will not be added to the ecosystem until the size range of prey taken by the cohort immediately preceeding is beyond that of the new cohort. In this way intraspecific competition for food is minimized.

Our data support this idea. Cohorts of capelin (hatched at about 5 mm) during 1975 and 1976 showed a mean spacing of 10.1 days; whereas, herring cohorts (hatched at about 7mm) during 1973 and 1974 were separated by 21.5 days on average. In addition, we investigated annual within-species variability in cohort spacing and were able to show that cohort separation was related to growth rate - the faster the growth, the closer the cohorts (Fig. 26). Thus cohort spacing is a function of two factors. The initial separation is species specific and a function of larval mouth size, thus being a product of evolution. Secondarily there is a proximal fine tuning by a factor or factors effected through larval growth rate.

An hypothesis concerning the mechanism governing this growth rate/cohort spacing relationship is proposed by Lambert and Ware (1982). They describe a compensatory mechanism which increases recruitment at low stock levels.

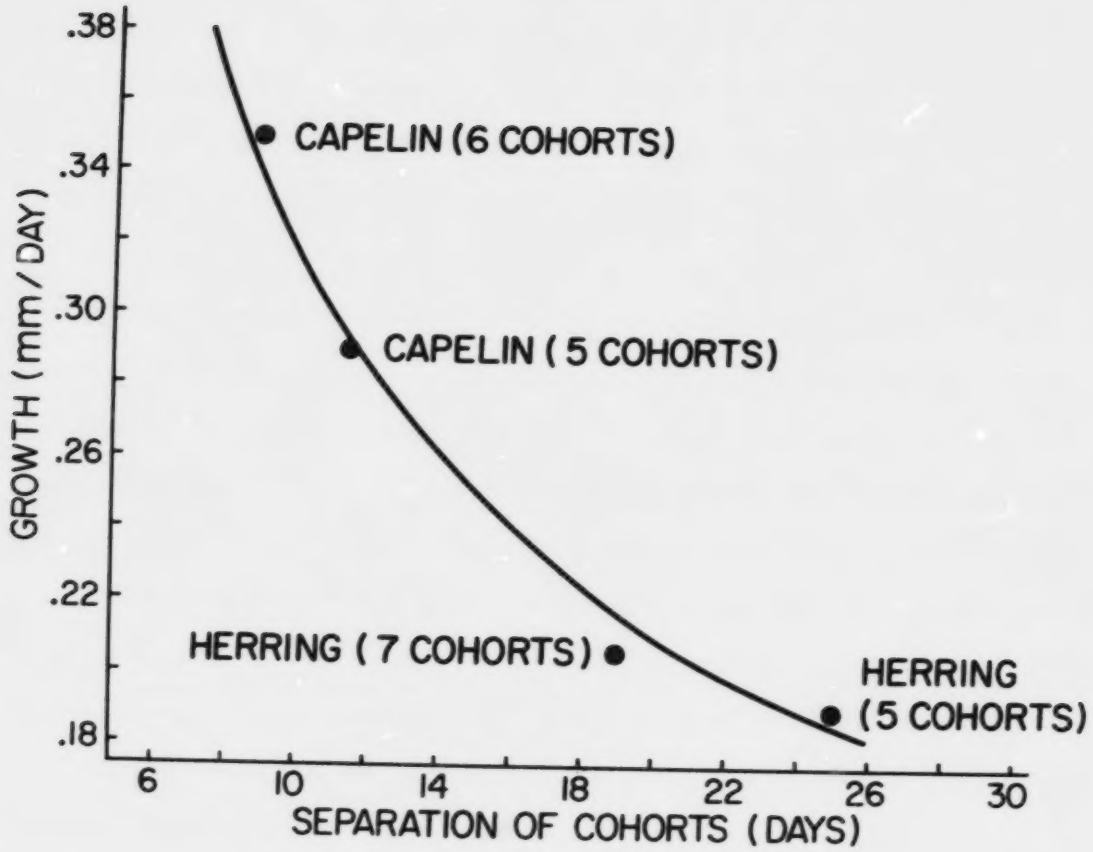


Fig. 26. Relationship between larval growth rate and spacing of larval cohorts.

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APPENDIX I

Estimation of the concentration (number/m^3) at 15 m depth.

C = concentration

$\bar{C}$ = mean concentration

IKMT = Isaacs-Kidd mid-water trawl towed obliquely, 0-20 metres.

subscripts are metres

$$\bar{C}_{(0-10)} = \frac{\frac{C_{(0)} + C_{(5)}}{2} + \frac{C_{(5)} + C_{(10)}}{2}}{2}$$

$$C_{(IKMT)} = \frac{\bar{C}_{(0-10)} + \bar{C}_{(10-20)}}{2}$$

$$C_{(15)} = \bar{C}_{(10-20)} = 2C_{(IKMT)} - \bar{C}_{(0-10)}$$

APPENDIX II

Herring maturity scale adopted by the ICES Committee (Anon 1962).

In the text ripe/running refers to stages V and VI; spent/recovering refers to stages VII and VIII.

Stage

I Virgin herring. Gonads very small, threadlike, 2-3 mm broad. Ovaries wine red. Testes whitish or grey brown.

II Virgin herring with small sexual organs. The height of ovaries and testes about 3-8 mm. Eggs not visible to naked eye but can be seen with magnifying glass. Ovaries a bright red colour; testes a reddish grey colour.

III Gonads occupying about half of the ventral cavity. Breadth of sexual organs between 1 and 2 cm. Eggs small but can be distinguished with naked eye. Ovaries orange; testes reddish grey or greysih.

IV Gonads almost as long as body cavity. Eggs larger, varying in size, opaque. Ovaries orange or pale yellow; testes whitish.

V Gonads fill body cavity. Eggs large, round; some transparent. Ovaries yellowish; testes milkwhite. Eggs and sperm do not flow, but sperm can be extruded by pressure.

VI Ripe gonads; eggs transparent; testes white; eggs and sperm flow freely.

VII Spent herring. Bonads baggy and bloodshot. Ovaries empty or containing only a few residual eggs. Testes may contain remains of sperm.

VIII Recovering spents. Ovaries and testes firm and larger than virgin herring in Stage II. Eggs not visible to naked eye. Walls of gonads striated; blood vessels prominent. Gonads wine red colour. (This stage passes into Stage III.)

APPENDIX III

Length/frequencies of herring and capelin larvae occurring in St. Georges Bay, N.S.; 1973-1976.

Herring 1973

Total Length	June 1	June 7	June 21	June 29	July 10
	0 IK	0 IK	0 IK	0 IK	0 IK
8 mm					
9 mm					
10 mm					
11 mm					
12 mm					
13 mm					
14 mm					
15 mm					
16 mm					
17 mm					
18 mm					
19 mm					
20 mm				1	
21 mm				1	
22 mm					
23 mm					
24 mm		1			
25 mm	1				
26 mm	3	1	2		
27 mm	1	2			
28 mm	3	1			
29 mm	6	4			
30 mm	15	1 2	1	1 2	
31 mm	5	1 2		4	1
32 mm	11	1 4		1 5	
33 mm	14	4		4	
34 mm	3	2		1 7	
35 mm	7	1 1		2	
36 mm	1			4	
37 mm	2	1		2	
38 mm	1 1	1		5	
39 mm	1			1	
40 mm				5	
41 mm				2	
42 mm				1	
43 mm					
44 mm					
45 mm	1	1			
Totals	75	22	1	36	46	1

Herring 1973

Total Length	July 20		July 26		August 1		August 3		August 8	
	0	IK	0	IK	0	IK	0	IK	0	IK
8 mm										
9 mm										
10 mm					1					
11 mm										
12 mm										
13 mm						16				
14 mm						8				
15 mm						16				
16 mm						20				
17 mm						8				
18 mm										
19 mm										
20 mm										
21 mm										
22 mm										
23 mm										
24 mm										
25 mm										
26 mm										
27 mm										
28 mm										
29 mm										
30 mm										
31 mm										
32 mm										
33 mm										
34 mm										
35 mm										
36 mm										
37 mm										
38 mm										
39 mm										
40 mm										
41 mm										
42 mm										
43 mm										
44 mm										
45 mm										
Totals					1	68				

Herring 1973

Total Length	August 20		October 3		October 25		December 9	
	0	IK	0	IK	0	IK	0	IK
8 mm			3					
9 mm						1		
10 mm								
11 mm			2		1	1		
12 mm			2			2		
13 mm		8				2		2
14 mm						3		1
15 mm		46			1	9		11
16 mm		9	2			8		18
17 mm		22			1	7	2	22
18 mm		21	2			19		31
19 mm		9				3		12
20 mm		24			2	21	17	12
21 mm		10			1	5	1	7
22 mm		4				9	2	17
23 mm		2				3	7	23
24 mm							7	21
25 mm					1	3	42	28
26 mm						2	21	26
27 mm					2	1	25	9
28 mm							24	12
29 mm					2		5	10
30 mm					1		19	22
31 mm							10	2
32 mm							11	1
33 mm							2	3
34 mm							2	2
35 mm							7	1
36 mm							4	2
37 mm								1
38 mm							3	4
39 mm							2	
40 mm							1	2
41 mm							2	
42 mm								
43 mm								
44 mm								
45 mm								
Totals	155		11		12	99	216	302

Herring 1974

Total Length	June 14				June 25				July 4				July 11				July 29			
	0	5	10	IK	0	5	10	IK	0	5	10	IK	0	5	10	IK	0	5	10	IK
6 mm																				
7 mm																				
8 mm										1										
9 mm													1							
10 mm													6							
11 mm													2							
12 mm																				
13 mm																	2			
14 mm																				
15 mm																				
16 mm																				
17 mm																				
18 mm																				
19 mm																				
20 mm																	1			
21 mm																				
22 mm																				
23 mm																				
24 mm																				
25 mm																				
26 mm																				60
27 mm																				
28 mm				1																
29 mm				1																
30 mm																				
31 mm																				
32 mm																				
33 mm																				
34 mm				1																
35 mm				3		1				2										
36 mm				3						1										
37 mm		2		3		1				1						4				
38 mm		1	1																	8
39 mm		1																		
40 mm		1		2																
41 mm		1		1		2														
42 mm				1																
43 mm				1		1														
44 mm																				
45 mm				4																
46 mm																				
47 mm				1																
Totals		6	1	22		5				4	1			9		4		3		8

Herring 1974

Total Length	August 8				August 13				August 20				September 11				September 25			
	0	5	10	IK	0	5	10	IK	0	5	10	IK	0	5	10	IK	0	5	10	IK
6 mm															1					
7 mm														3	13	2				
8 mm														12	48					
9 mm														10	39	8				
10 mm										4				14	30	9				
11 mm														3	10	2				
12 mm													1	2	4	2				
13 mm													3	1	1	1				
14 mm				1				1							1	1				
15 mm								2				1				3				
16 mm								1		4			1		3	1				
17 mm														1	1	3				
18 mm														2		6				
19 mm																	1			
20 mm																	1			
21 mm																	1			
22 mm																				
23 mm																				
24 mm																				
25 mm																				
26 mm																				
27 mm																				
28 mm																				
29 mm																				
30 mm																				
31 mm																				
32 mm																				
33 mm																				
34 mm																				
35 mm																				
36 mm																				
37 mm																				
38 mm																				
39 mm																				
40 mm																				
41 mm																				
42 mm																				
43 mm																				
44 mm																				
45 mm																				
46 mm																				
47 mm																				
Totals				1				4		8		1		6		5		2	47	152	47

Herring 1974

Total Length	October 7				November 20				December 12			
	0	5	10	IK	0	5	10	IK	0	5	10	IK
6 mm		4	1									
7 mm	1	5	8			2	2					1
8 mm	1	12	25			10	12	4			2	
9 mm	1	9	19			11	33	3	5	1		
10 mm		1	10			9	26	8	5	1		
11 mm	2	4	9			13	19	4	2	5	2	
12 mm	2	3	3			3	15	10		10	5	4
13 mm	3	2	1			23	35	19		11	3	11
14 mm			1		5	36	81	33		10	12	8
15 mm					4	41	92	28		12	12	3
16 mm					4	45	86	37		9	8	6
17 mm						12	55	30		13	19	15
18 mm					2	11	22	11		11	49	33
19 mm					3	11	16	13		19	62	54
20 mm					11	6	19	17		26	95	112
21 mm					9	6	11	17		15	103	98
22 mm					7	8	14	23		13	51	94
23 mm	1				12	8	2	24		12	17	88
24 mm					17	7	1	8		5	2	56
25 mm					15	7	7	37		5	12	54
26 mm					6		2	22		12	14	67
27 mm	1				4			13		6	29	51
28 mm					3			20		2	15	77
29 mm					1			1		1	9	30
30 mm					1	1		13		1	19	24
31 mm								3		1	5	16
32 mm								3		1	2	8
33 mm											2	2
34 mm										1		6
35 mm											1	3
36 mm												
37 mm												1
38 mm												3
39 mm												
40 mm												2
41 mm												
42 mm												
43 mm												
44 mm												
45 mm												
46 mm												
47 mm												
Totals	12	40	77		104	270	550	404	12	203	550	927

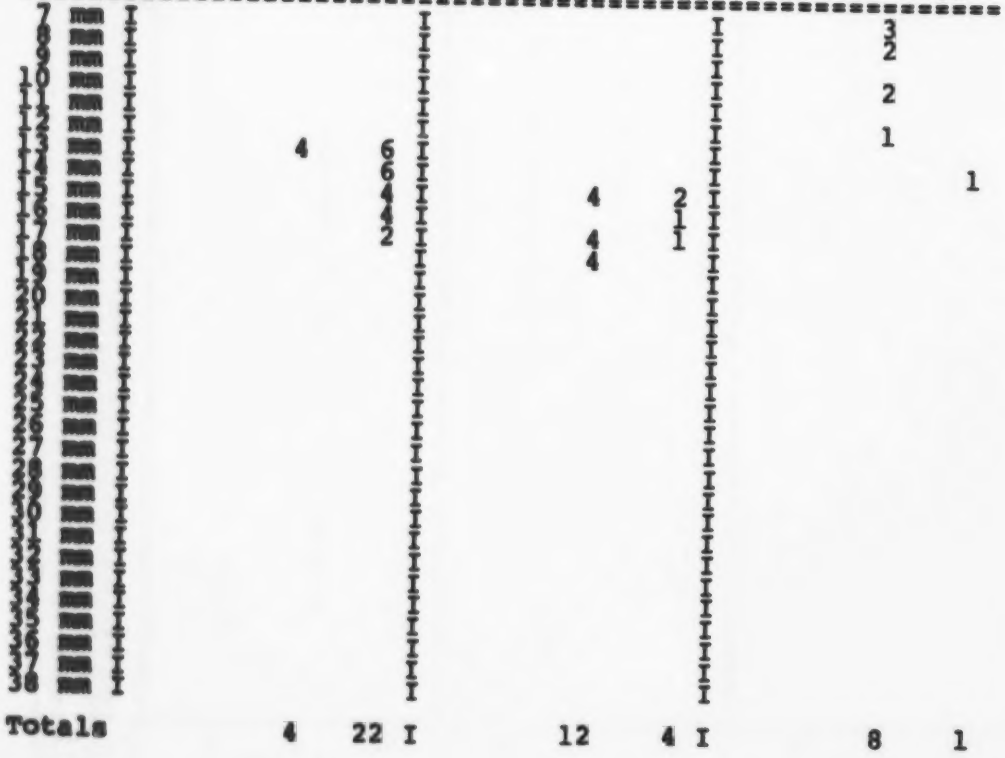
Herring 1975

Total Length	June 12			June 18			June 24			July 3			July 8		
	0	10	IK	0	10	IK	0	10	IK	0	10	IK	0	10	IK
7 mm															
8 mm															
9 mm															
10 mm															
11 mm															
12 mm															
13 mm															
14 mm															
15 mm															
16 mm															
17 mm															
18 mm															
19 mm															
20 mm															
21 mm															
22 mm															
23 mm															
24 mm															
25 mm															
26 mm															
27 mm															
28 mm															
29 mm															
30 mm															
31 mm															
32 mm															
33 mm															
34 mm		1													
35 mm															
36 mm															
37 mm															
38 mm								1							
Totals		1						1							

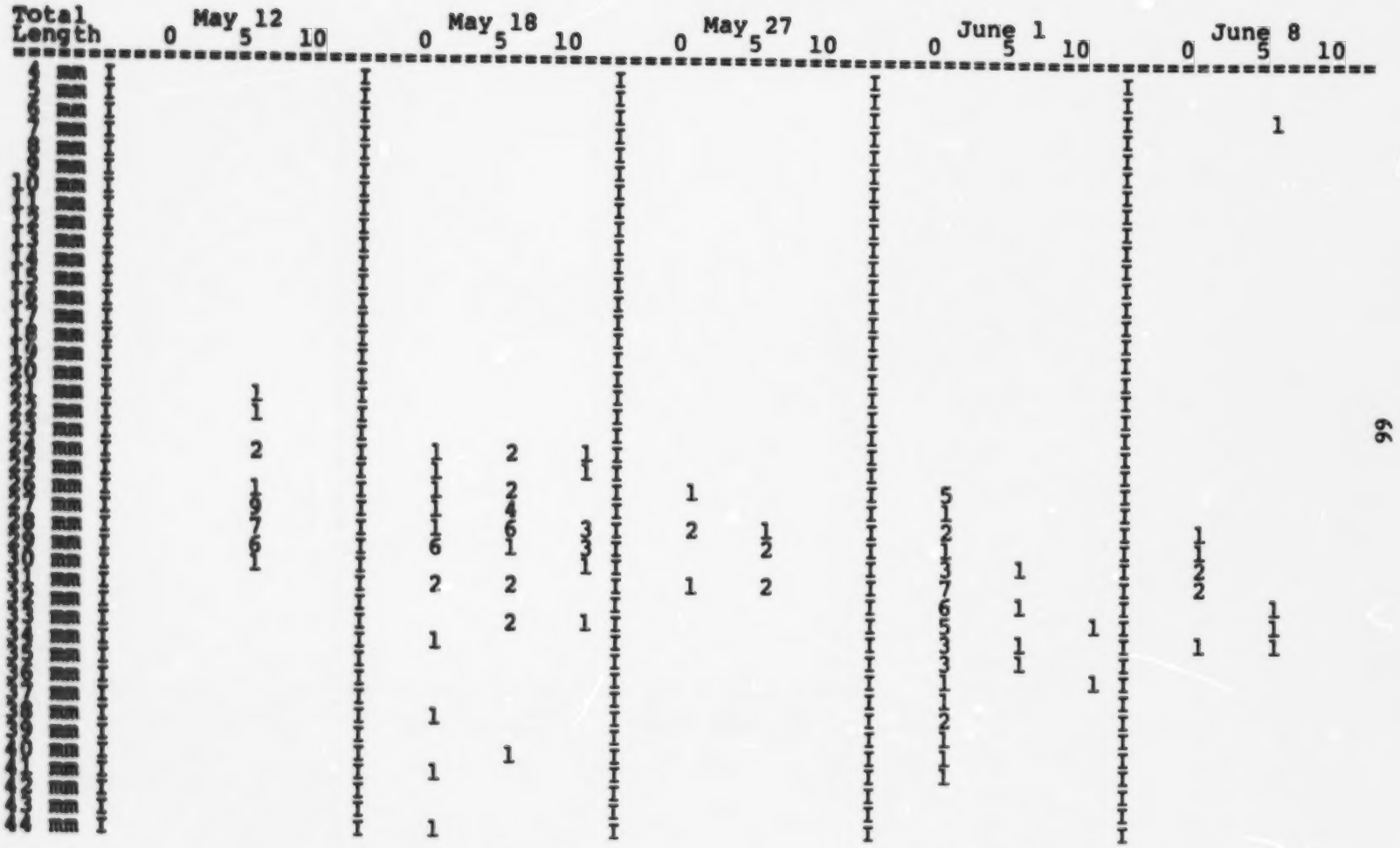
Herring 1975

Total Length	July 15			July 23			July 31			August 6			August 12			
	0	10	IK	0	10	IK	0	10	IK	0	10	IK	0	10	IK	
7 mm																
8 mm											8					
9 mm																
10 mm																
11 mm															2	
12 mm														4	1	
13 mm												1				
14 mm																
15 mm															2	49
16 mm																
17 mm																
18 mm																
Totals											8	1		4	5	

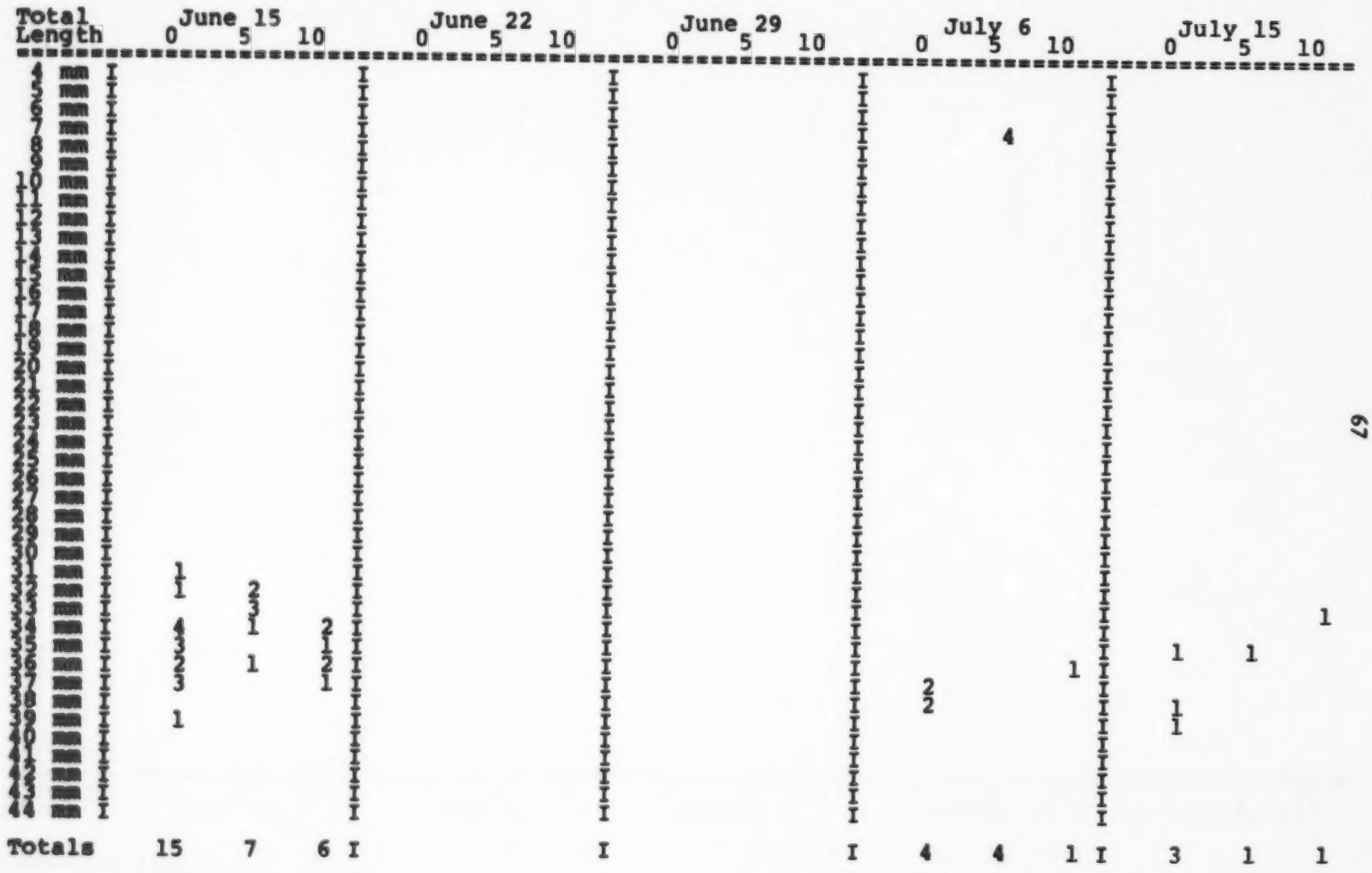
Herring 1975



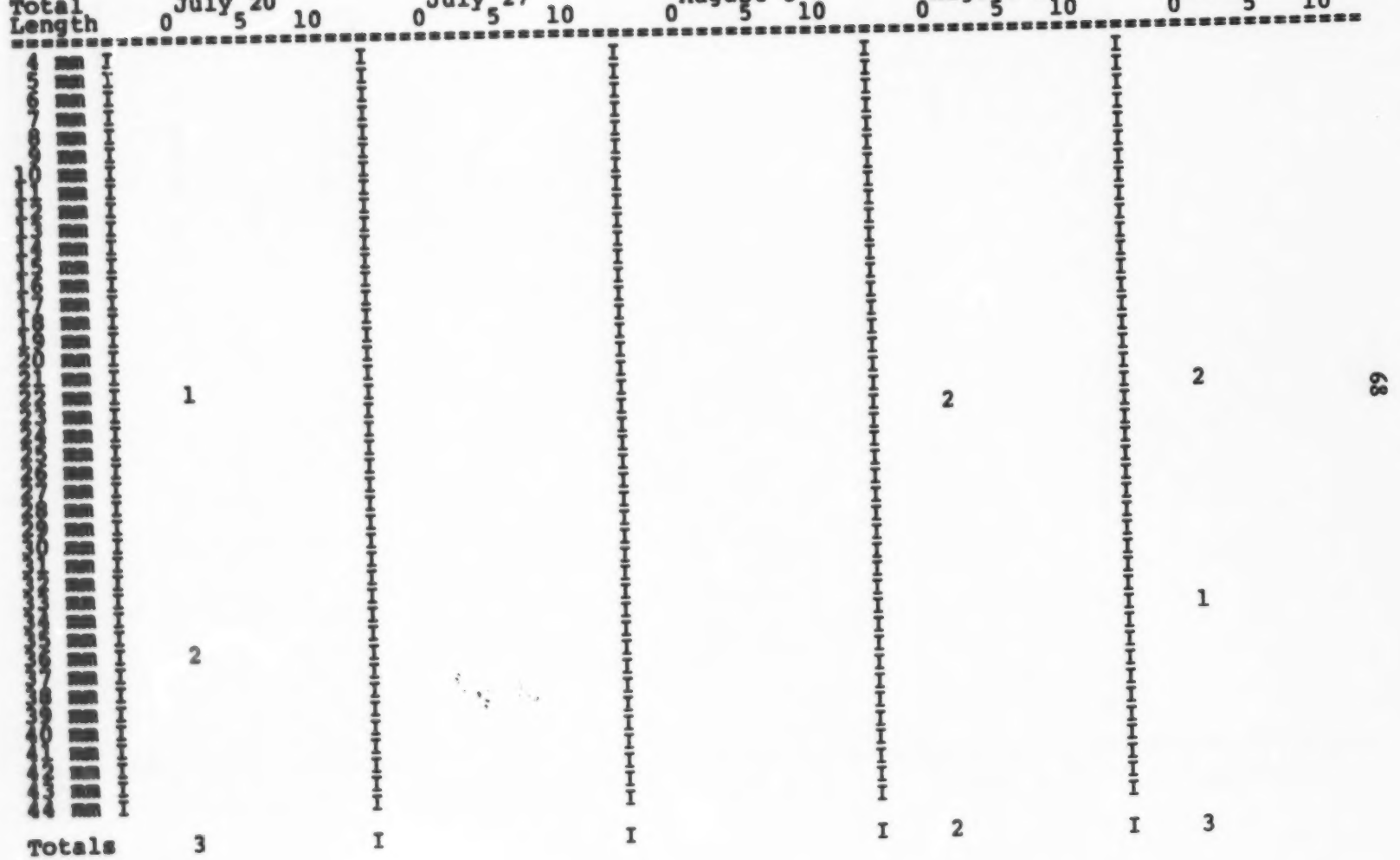
Herring 1976



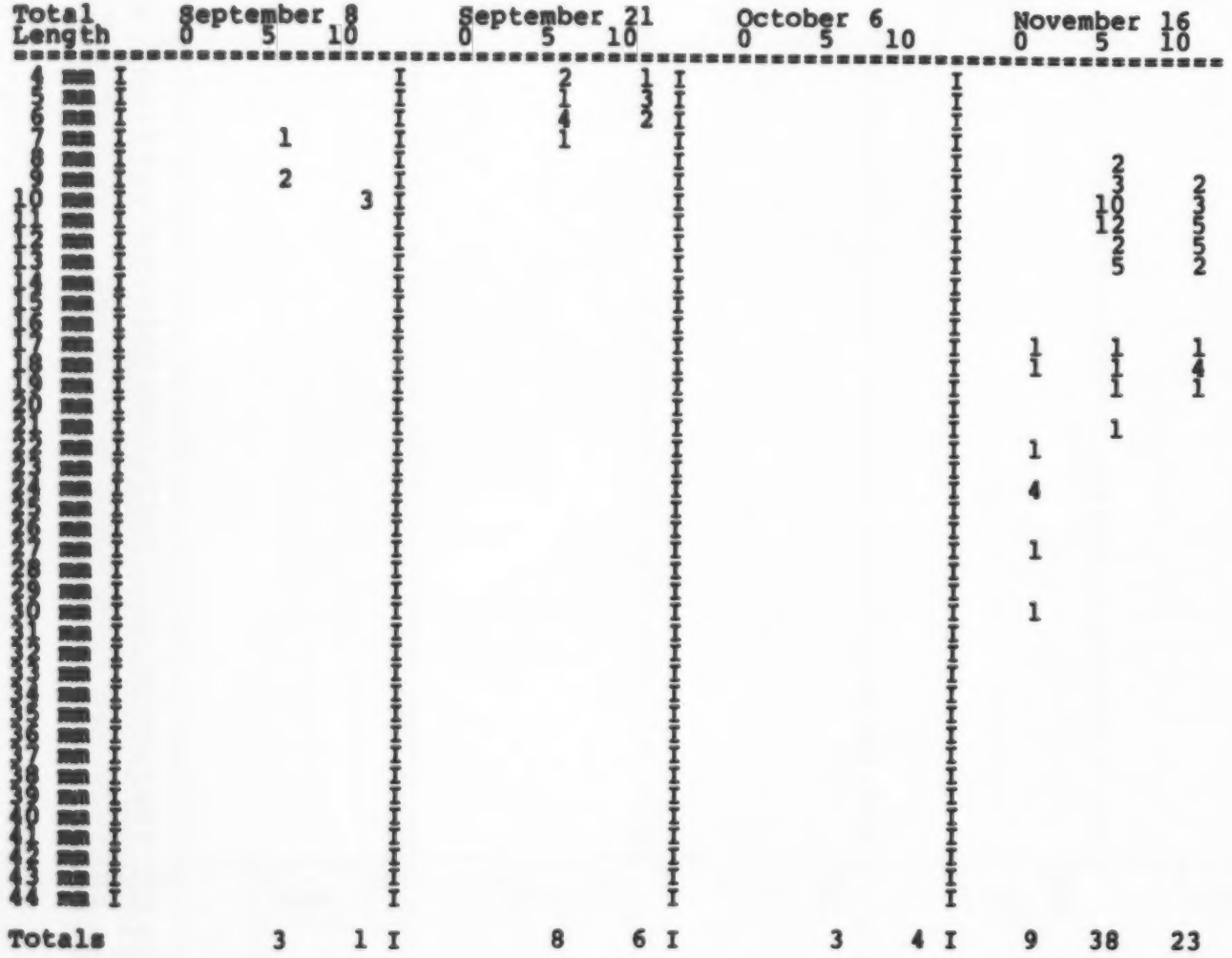
Herring 1976



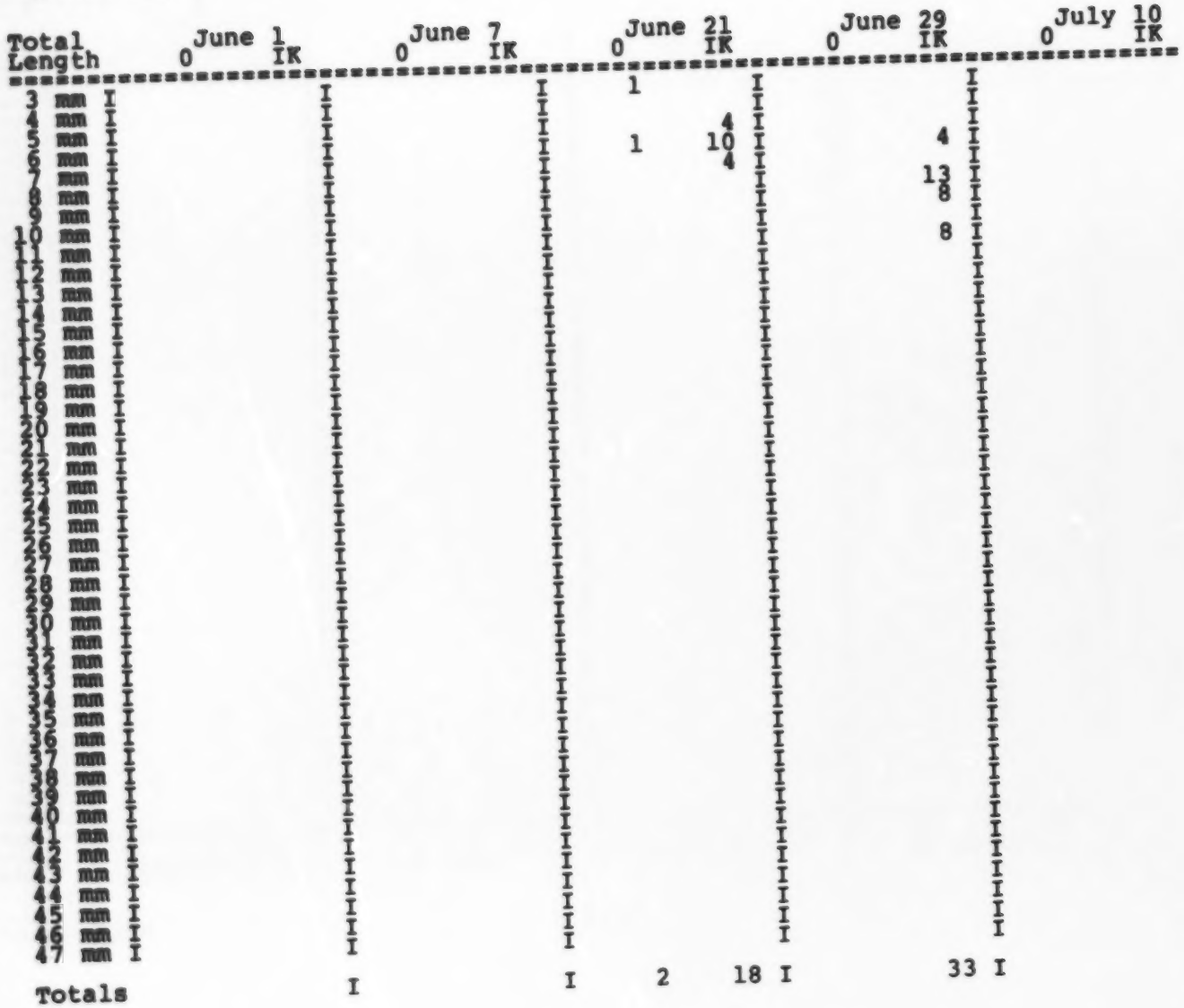
Herring 1976



Herring 1976



Capelin 1973



Capelin 1973

Total Length	July 20		July 26		August 1		August 3		August 8	
	0	IK	0	IK	0	IK	0	IK	0	IK
3 mm	I		I		I		I			
4 mm	I		I		I		I			
5 mm	I		I		I		I			
6 mm	I		I		I		I			
7 mm	I		I		I		I			
8 mm	I		I		I		I			
9 mm	I		I		I		I			
10 mm	I		I		I		I			
11 mm	I		I		I		I			
12 mm	I		I		I		I			
13 mm	I		I		I		I			
14 mm	I		I		I		I			
15 mm	I		I		I		I			
16 mm	I		I		I		I			
17 mm	I		I		I		I			
18 mm	I		I		I		I			
19 mm	I		I		I		I			
20 mm	I		I		I		I			
21 mm	I		I		I		I			
22 mm	I		I		I		I			
23 mm	I		I		I		I			
24 mm	I		I		I		I			
25 mm	I		I		I		I			
26 mm	I		I		I		I			
27 mm	I		I		I		I			
28 mm	I		I		I		I			
29 mm	I		I		I		I			
30 mm	I		I		I		I			
31 mm	I		I		I		I			
32 mm	I		I		I		I			
33 mm	I		I		I		I			
34 mm	I		I		I		I			
35 mm	I		I		I		I			
36 mm	I		I		I		I			
37 mm	I		I		I		I			
38 mm	I		I		I		I			
39 mm	I		I		I		I			
40 mm	I		I		I		I			
41 mm	I		I		I		I			
42 mm	I		I		I		I			
43 mm	I		I		I		I			
44 mm	I		I		I		I			
45 mm	I		I		I		I			
46 mm	I		I		I		I			
47 mm	I		I		I		I			
Totals			I		I		I			

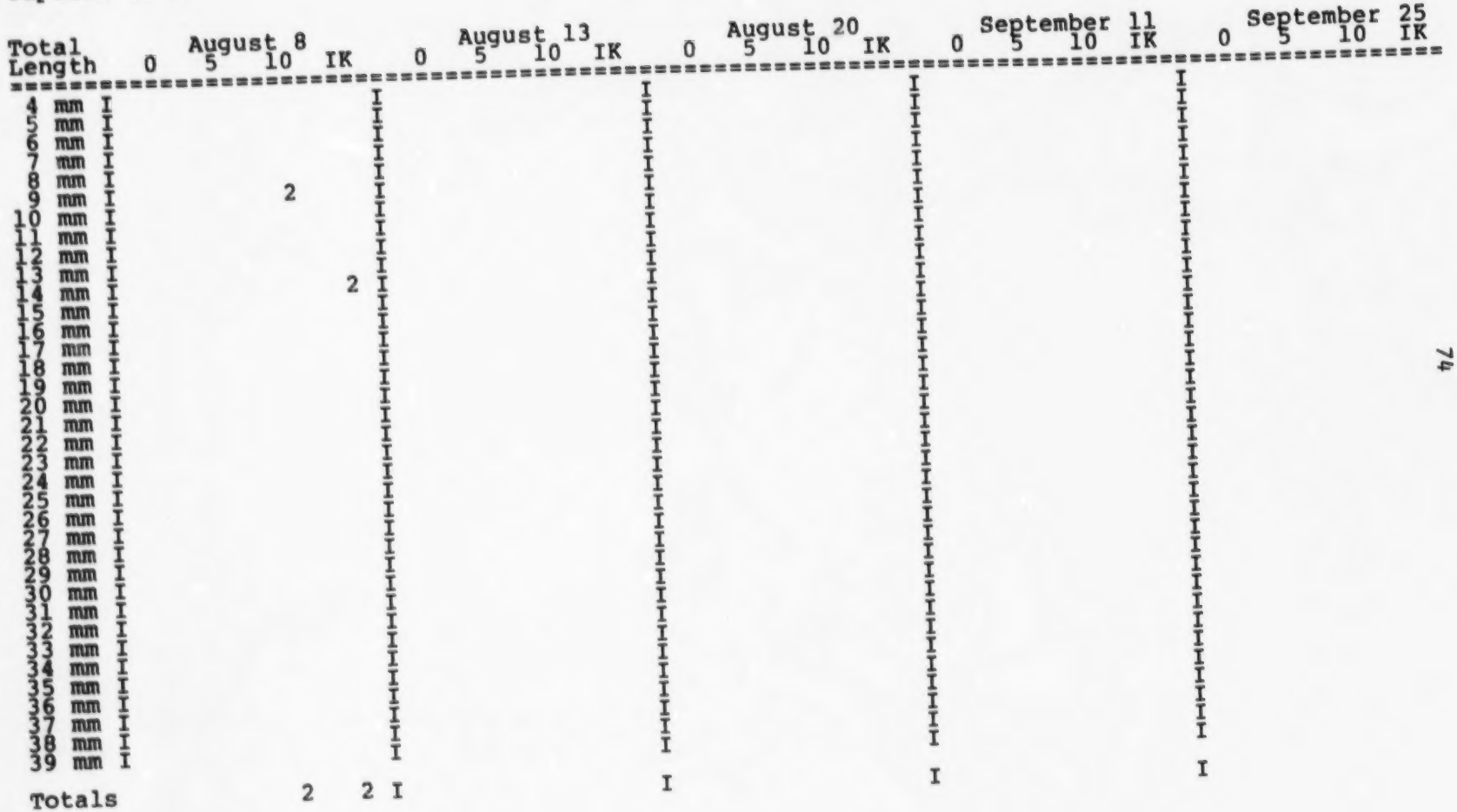
Capelin 1973

Total Length	August 20		October 3		October 25		December 9	
	0	IK	0	IK	0	IK	0	IK
8 mm								
9 mm								
10 mm								
11 mm								
12 mm								
13 mm					1			
14 mm								
15 mm								
16 mm								
17 mm								
18 mm					1			
19 mm								
20 mm								
21 mm								
22 mm								
23 mm								
24 mm					2			
25 mm								
26 mm					2			1
27 mm								
28 mm								
29 mm					1			
30 mm		4						
31 mm								
32 mm					1			
33 mm								1
34 mm							1	
35 mm								
36 mm								
37 mm							3	1
38 mm								
39 mm								
40 mm								
41 mm								
42 mm					1			
43 mm							1	
44 mm							1	
45 mm					1		1	
46 mm								
47 mm								
48 mm							2	
49 mm							1	
50 mm							1	
51 mm							1	
52 mm								
Totals		4			10		12	3

Capelin 1974

Total Length	June 14			June 25			July 4			July 11			July 29		
	0	5	10	IK	0	5	10	IK	0	5	10	IK	0	5	10	IK	0	5	10	IK
4 mm							8					4								
5 mm						7	63			1	30	9								1
6 mm		2	1		1	6	102			6	75	2								
7 mm			1			8	235			10	81	7		12	4					1
8 mm						2	111			17	68	3		21	6				1	
9 mm						1	48		1	10	25	4		12	6			8	9	
10 mm							2			2	5	3		20	8					
11 mm						1					1			16	8				16	
12 mm							6							24	5			8		
13 mm										1	1			4	6					
14 mm																				2
15 mm																		8		
16 mm																				1
17 mm																				
18 mm																				73
19 mm																				
20 mm																				
21 mm																				
22 mm																				
23 mm																				
24 mm																				
25 mm																				8
26 mm																				
27 mm																				
28 mm																				
29 mm																				
30 mm																				
31 mm																				
32 mm																				
33 mm																				
34 mm																				
35 mm																				
36 mm																				
37 mm																				
38 mm																				
39 mm																				
Totals		2	2			25	575	1		1	47	286	32			109	43			24	26	13

Capelin 1974



Capelin 1974

Total Length	October 7				November 20				December 12			
	0	5	10	IK	0	5	10	IK	0	5	10	IK
4 mm												
5 mm												
6 mm												
7 mm												
8 mm												
9 mm												
10 mm												
11 mm												
12 mm												
13 mm												
14 mm												
15 mm												
16 mm												
17 mm												
18 mm												
19 mm												
20 mm												
21 mm												
22 mm												
23 mm												
24 mm												
25 mm												
26 mm												
27 mm												
28 mm												
29 mm												
30 mm								1				
31 mm								1				
32 mm								1				
33 mm								2				1
34 mm												1
35 mm								1				
36 mm						1		2				
37 mm												
38 mm								1				
39 mm												2
Totals						1		9				4

Capelin 1975

Total Length	June 12			June 18			June 24			July 3			July 8		
	0	10	IK	0	10	IK	0	10	IK	0	10	IK	0	10	IK
4 mm		19						13			88	6		1	
5 mm	1	56			7	2	2	263	45	1	124	13	1	23	1
6 mm		10			22	7	4	937	149	4	141	11	1	34	2
7 mm					5	2	1	294	24		55	14	1	16	3
8 mm								37	9		24	5		17	7
9 mm								27	13		6	9		3	
10 mm								15	2		6	17			1
11 mm								2			4	7			2
12 mm								1				5			4
13 mm															4
14 mm															
15 mm															
16 mm															
17 mm															
18 mm															
19 mm															
20 mm															
21 mm															
22 mm															
23 mm															
24 mm															
25 mm															
26 mm															
27 mm															
Totals	1	85			34	11	7	1589	242	5	448	87	3	94	24

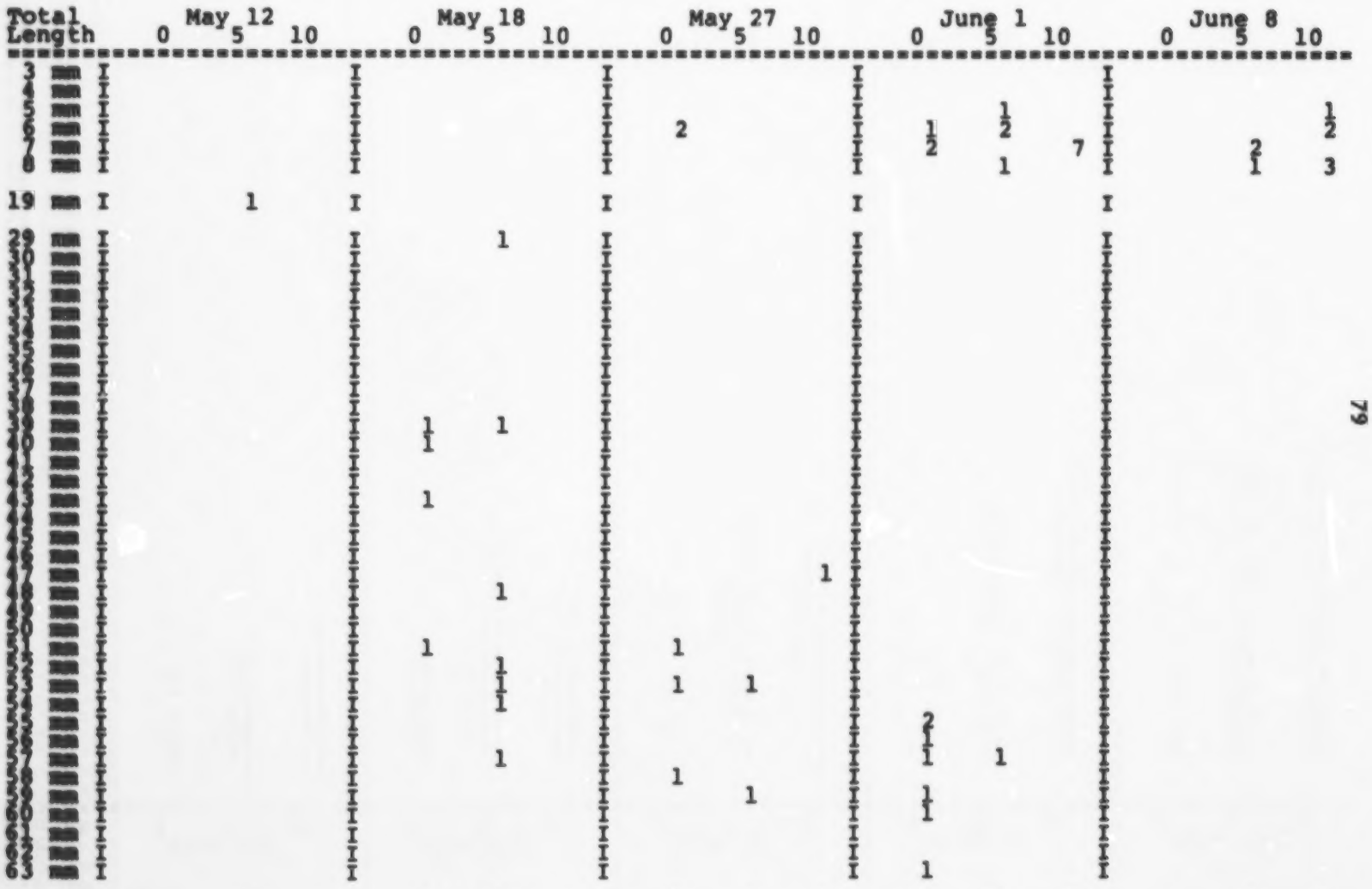
Capelin 1975

Total Length	July 15			July 23			July 31			August 6			August 12		
	0	10	IK	0	10	IK	0	10	IK	0	10	IK	0	10	IK
4															
5															
6															
7			1						4						
8		6							8						
9			2						8						2
10															
11			2		8	1									2
12			7												
13			3			1						16			6
14						4						16			4
15									1						4
16						4			2						
17									1			1			
18									3			3			1
19									2			12			
20															
21												1			1
22															
23															
24															
25															
26															
27															
Totals		6	15		8	10			29			49			20

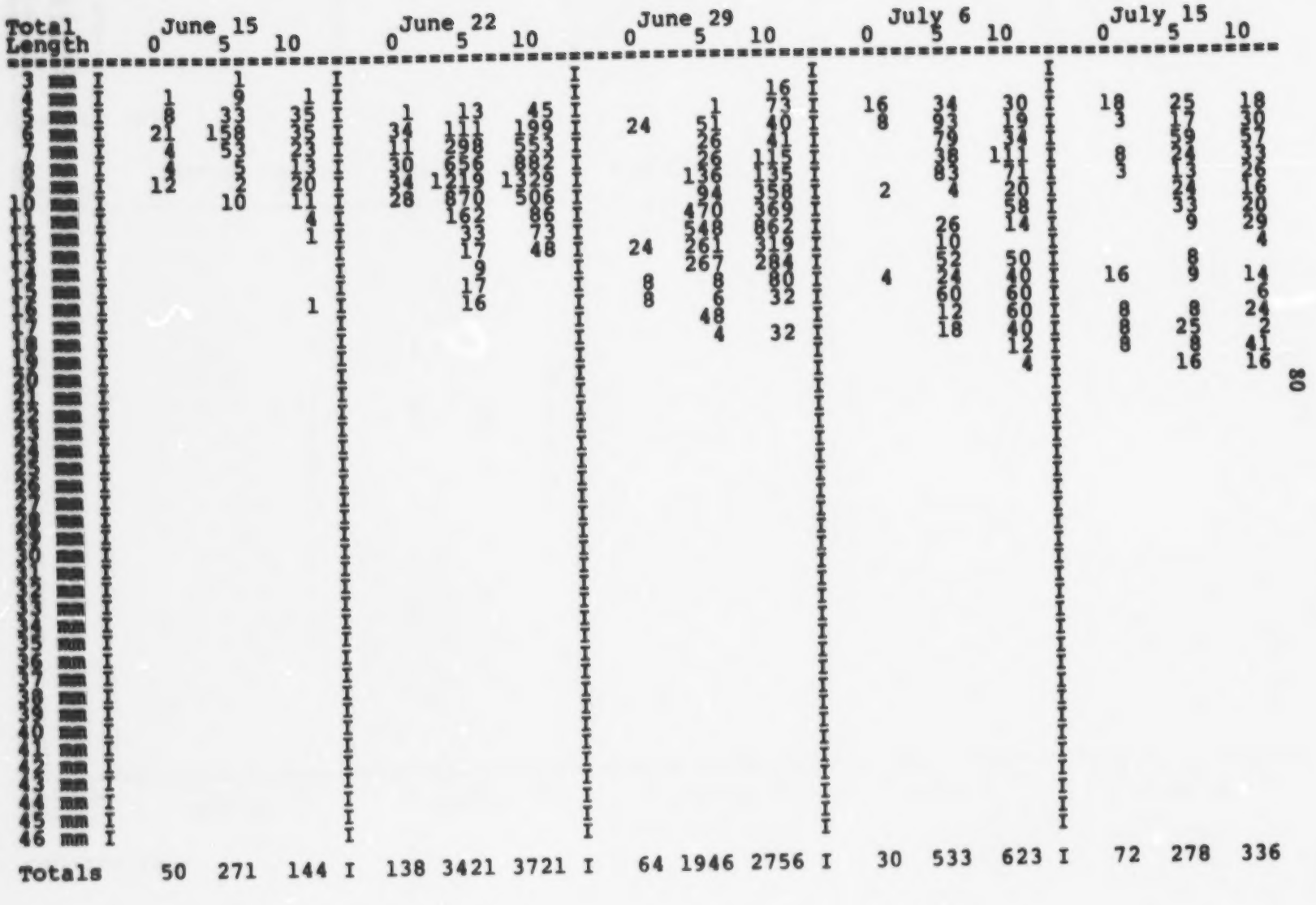
Capelin 1975

Total Length	August 19 0 10 IK	August 26 0 10 IK	September 23 0 10 IK
4			
5			
6			
7			
8			
9			
10			
11	4		
12			
13		2	
14	12		
15	9	1	
16	4	1	
17	4	6	
18	9	5	
19		4	
20	3		
21			
22			
23			
24			
25			
26			
27			1
Totals	45	19	1

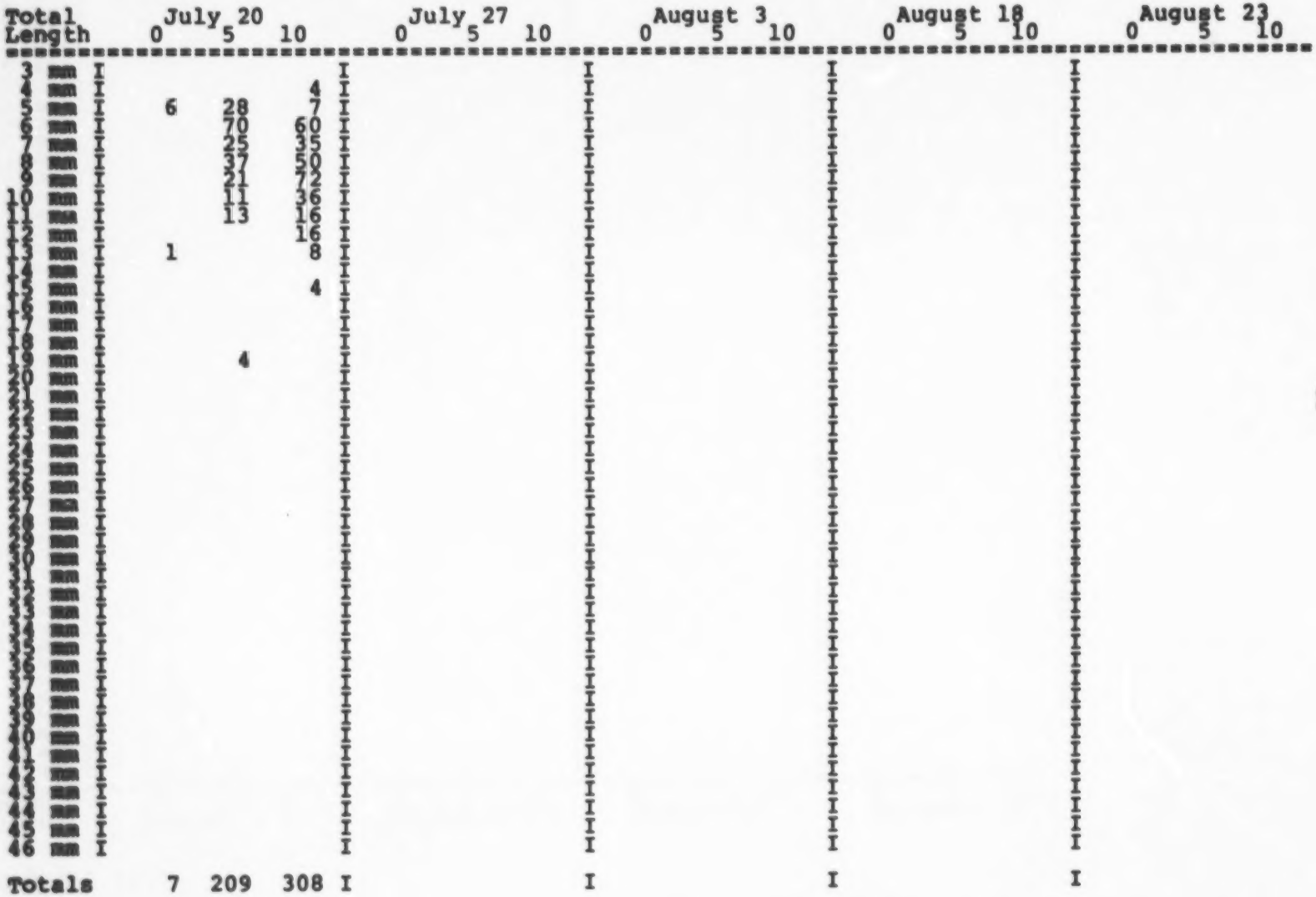
Capelin 1976



Capelin 1976



Capelin 1976



Capelin 1976